DOCUMENT RESUME

ED 144 468 HE 009 255

AUTHOR	Baer, Walter S.
TITLE	University Relationships with Other R&D Performers.
INSTITUTION	Rand Corp., Santa Monica, Calif.
REPORT NO	P-5780
PUB DATE	Jan 77
NOTE	70p.
AVAILABLE FROM	Rand Corporation, Santa Monica, California ($5.00)
EDRS PRICE	MF-$0.83 HC-$3.50 Plus Postage.
DESCRIPTORS	*College Role; Contracts; *Federal Aid; Federal Government; Financial Support; Government Role; Grants; *Higher Education; Research and Development Centers; *Research Projects; *School Industry Relationship; Universities
IDENTIFIERS	Competition; *Research and Development; *Technology Transfer

ABSTRACT

Historically, universities have been the principal performers of basic research in the United States, but they are now joined by federal government laboratories, independent research centers, and industrial laboratories. This paper reviews the available data on issues concerning the distribution of R&D resources among cate- gories of research performers. It then discusses the changing relationships and increased competition between universities and other R&D performers. Focus is on changes and trends in university-industry relationships in the past 10 years, includ- ing weakened bonds from 1945 to 1970, international comparisons, prospects for closer relationships, and encouragement of university-industry knowledge transfer. It is concluded that universities and private sector firms seem anxious to rediscover and reinforce the ties between them. Specific government programs may help, but their importance is not clear. Effective university-industry links depend most on the two partners' own incentives to promote the flow of people and ideas. (Author/LBH)

****
* Documents acquired by ERIC include many informal unpublished *
* materials not available from other sources. ERIC makes every effort *
* to obtain the best copy available. Nevertheless, items of marginal *
* reproducibility are often encountered and this affects the quality *
* of the microfiche and hardcopy reproductions ERIC makes available *
* via the ERIC Document Reproduction Service (EDRS). EDRS is not *
* responsible for the quality of the original document. Reproductions *
* supplied by EDRS are the best that can be made from the original. *
****

ED144468

UNIVERSITY RELATIONSHIPS WITH OTHER R&D PERFORMERS

Walter S. Baer

January 1977

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
NATIONAL INSTITUTE OF EDUCATION

THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL NATIONAL INSTITUTE OF EDUCATION POSITION OR POLICY

HE009255

P 5780

The Rand Paper Series

Papers are issued by The Rand Corporation as a service to its professional staff. Their purpose is to facilitate the exchange of ideas among those who share the author's research interests; Papers are not reports prepared in fulfillment of Rand's contracts or grants. Views expressed in a Paper are the author's own, and are not necessarily shared by Rand or its research sponsors.

The Rand Corporation
Santa Monica, California 90406

CONTENTS

INTRODUCTION 1
The "traditional" relationships 3
Federalizing University R&D after 1945 4

FUNDS FOR UNIVERSITIES AND OTHER R&D PERFORMERS 7
Changes in R&D Spending Among Performers Since 1966 13
Changes in Federal Agency Support of R&D Performers Since 1966 15

CHANGING RELATIONSHIPS BETWEEN UNIVERSITIES AND OTHER R&D PERFORMERS 20
University Contract Research Centers: Moving Classified Research Off Campus 21
University Administered FFRDCs 24
Project Research Institutes 27
Competition Among Research Performers 29

UNIVERSITY RELATIONSHIPS WITH INDUSTRY 31
Weakened Bonds: 1945-1970 32
International Comparisons 36
Prospects for Closer Relationships 37
Encouraging University-Industry Knowledge Transfer 47

CONCLUSIONS: MAINTAINING A STRONG UNIVERSITY ROLE IN A PLURALISTIC R&D SYSTEM 54

UNIVERSITY RELATIONSHIPS WITH OTHER R&D PERFORMERS[1]

INTRODUCTION

Historically, universities have been the principal performers of basic research in the United States, the "home of science."[2] But other institutions have played significant roles in scientific research as well, with roots tracing back to the nineteenth century: the Smithsonian Institution, and federal government laboratories in the Department of Agriculture (USDA), the Coast Survey, and the Geological Survey; independent research centers including the Franklin Institute and Arthur D. Little, Inc.; and industrial laboratories maintained by companies such as duPont and General Electric. Pluralism in the conduct of R&D has been a fundamental characteristic of the American research system.

Other papers in this series have documented the problems universities have faced from the decline (in constant dollars) in federal expenditures for research and development since the mid-1960s. Scientists and research administrators in government laboratories, industry, and nonprofit institutes tell the same story, however. Research budgets are down. Good researchers have been let go or turned away. For every university that has reached its tenure ceiling, one can cite an industrial, government, or nonprofit laboratory with a hiring freeze. Plans to build new research facilities, purchase new equipment, and extend research into new areas have been deferred or cancelled in every sector of the research community. By no means have universities borne

---

[1]This paper has been prepared for the American Association of Universities' (AAU) project on "The Future Research Role of Universities." An abridged and edited version of the paper will appear in the final report from the AAU project, to be published in 1977. The views expressed here are those of the author and are not necessarily shared by the AAU, The Rand Corporation, or any of their research sponsors.

[2]Wolfle, D., *The Home of Science*, McGraw-Hill Book Company, New York, 1972.

the burdens alone.

Still, one can ask whether universities have fared better or worse than other R&D performers of research and development in the United States. Have federal funds for basic research been transferred from universities to government laboratories, industrial firms, or other research performers? Which federal agencies have increased or de-emphasized R&D at universities during the past decade? What has happened to industrial support of academic R&D and other links between universities and the private sector?

This paper reviews the available data on these and related issues concerning the distribution of R&D resources among categories of research performers. It then discusses the changing relationships and increased competition between universities and other R&D performers. The next section focuses on changes and trends in university-industry relationships in the past ten years, followed by a final section summarizing the paper's findings and conclusions.

Any such discussion must begin with the observation that the United States has a richly diverse mix of colleges and universities. This paper is principally concerned with *research* relationships between universities and other institutions, rather than with the flow of students or employment patterns of research professionals. It therefore focuses on universities and other academic institutions performing research rather than on post-secondary institutions primarily engaged in teaching. Still, the university research sector contains public and private institutions with different objectives and approaches. Some universities have large agricultural and engineering research programs that traditionally have been linked closely with government and industry. Some dozens of universities have managed large programs of contract research for the Defense Department and other federal agencies, while others have avoided such commitments. Some universities have enthusiastically pursued "relevance" in research, while others have consciously eschewed it. Some universities actively encourage faculty members to seek industrial consulting or

engage in part-time entrepreneurship, while others frown on such activities. In short, the heterogeneity of American colleges and universities that represents one of the system's greatest strengths, ensures that any generalizations about university research relationships will have notable exceptions.

Other categories of research performers also comprise diverse institutions and have fuzzy boundaries. The industrial R&D sector contains firms tinkering with minor product improvements as well as institutions like the Bell Laboratories that support more basic research than most universities. Other sectors display a similarly wide range of attitudes and capabilities. In this paper, we adopt the categories of research performers defined by the National Science Foundation (NSF) in its publications on R&D resources. Besides universities, the categories include federal in-house laboratories, federally funded research and development centers (FFRDCs) managed by universities, industrial firms (including FFRDCs managed by industrial firms), and a residual category of other performers including independent research institutes, hospitals, and state and local government agencies. More precise definitions of these sectors can be found in the NSF annual series *Federal Funds for Research, Development, and Other Scientific Activities*.

The "traditional" relationships

American universities have traditionally sought and received support for scientific research from multiple sources, including federal and state government agencies, industrial firms, and private philanthropy. The Hatch Act of 1887 authorized USDA support for an agricultural experiment station at each land grant college, and university research in the fields of agriculture, geology, and meteorology has been closely tied to research carried out in federal government laboratories. University research in astronomy, on the other hand, received its initial support from philanthropic sources and has been linked with private, independent research institutions such as the Carnegie Institution of Washington.

And the Rockefeller Foundation was the driving force behind university research in experimental biology in the 1930s.[1]

The university's historical and still predominant interaction with industry has been as the supplier of trained manpower. But scientists in the United States have always had a practical bent, as de Tocqueville noted, and university professors have been far more willing to work on applied problems than their European counterparts.[2] As organized industrial research grew in the first decades of the twentieth century, industry interest in university research grew apace. By the 1940s the use of university faculty as consultants, industry support of specific university research projects and graduate fellowships, and some sharing of specialized research equipment had become "traditional" modes of industry-university interaction.

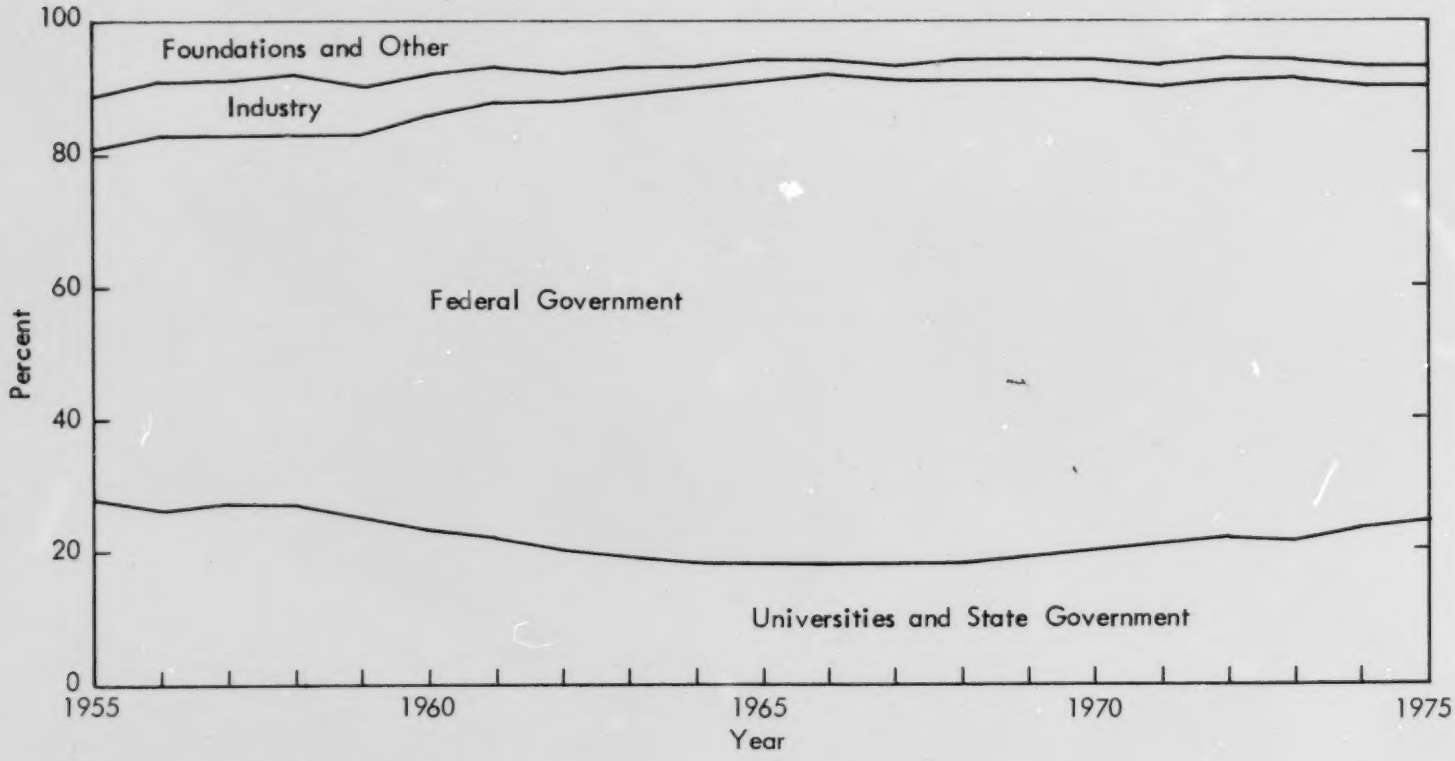
Federalizing University R&D After 1945

Federal support of R&D during and after World War II produced decisive changes in university relationships with other funding sources and R&D institutions. In line with the recommendations presented by Vannevar Bush in *Science the Endless Frontier*, federal agencies such as the Office of Naval Research, the National Science Foundation and the Atomic Energy Commission were established with explicit mandates to fund research in universities and other non-government facilities. By the early 1950s, the federal government had become the principal patron of university research, displacing the role previously held by university endowments and state funds. By 1966 the federal government supported 74 percent of all university R&D (Fig. 1), and 77 percent of basic research (Fig. 2) at colleges and universities.

---

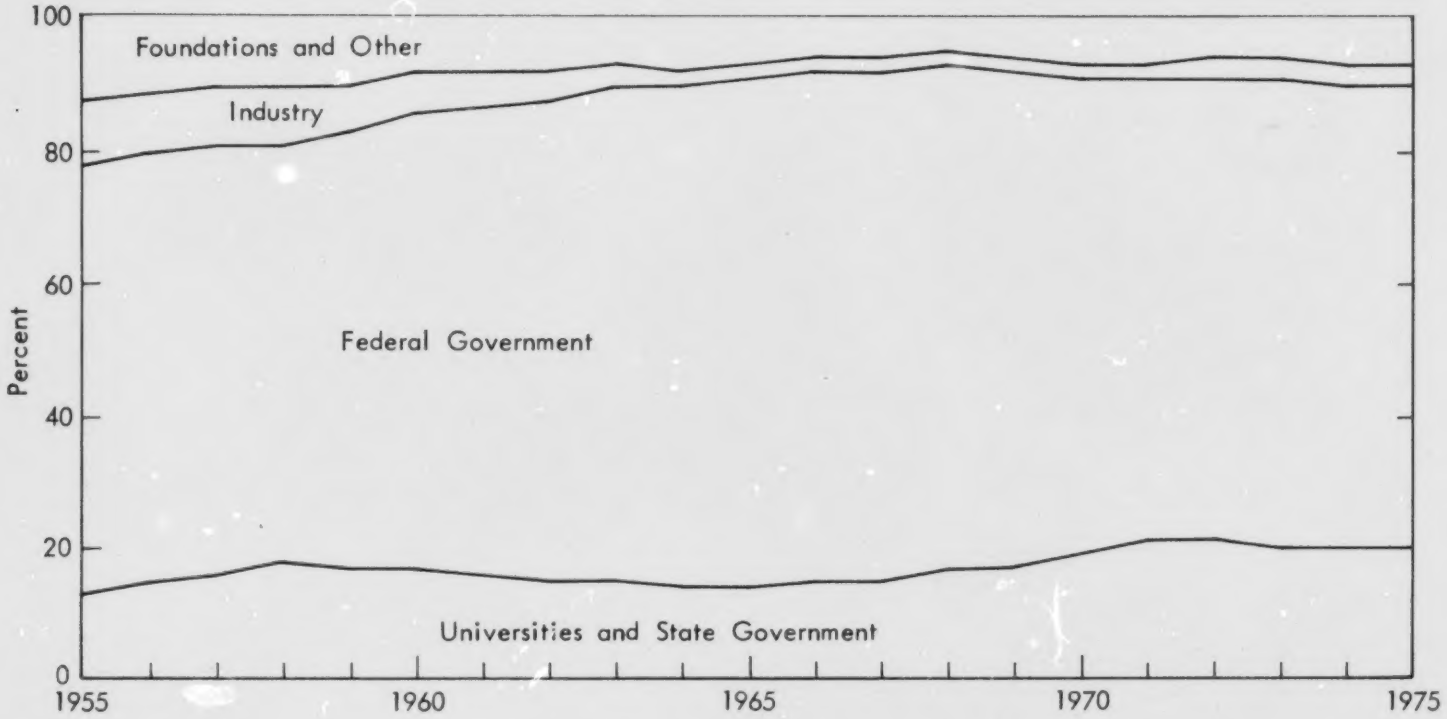
[1] Wolfle, D., op. cit., pp. 22-32, 53-56, 93.

[2] In the 1820s, for example, the builders of the Delaware and Hudson Canal reportedly sought consulting advice at Columbia University in developing their final engineering plans. See Alexander, Arthur J., "Cost Curves and Rate of Return on the Delaware and Hudson Canal 1831-1899," (processed).



Source: National Science Foundation

Fig. 1 — Sources of R & D funds for colleges and universities, 1955-1975



Source: National Science Foundation

Fig. 2 — Sources of basic research funds for Colleges and Universities, 1955 - 1975

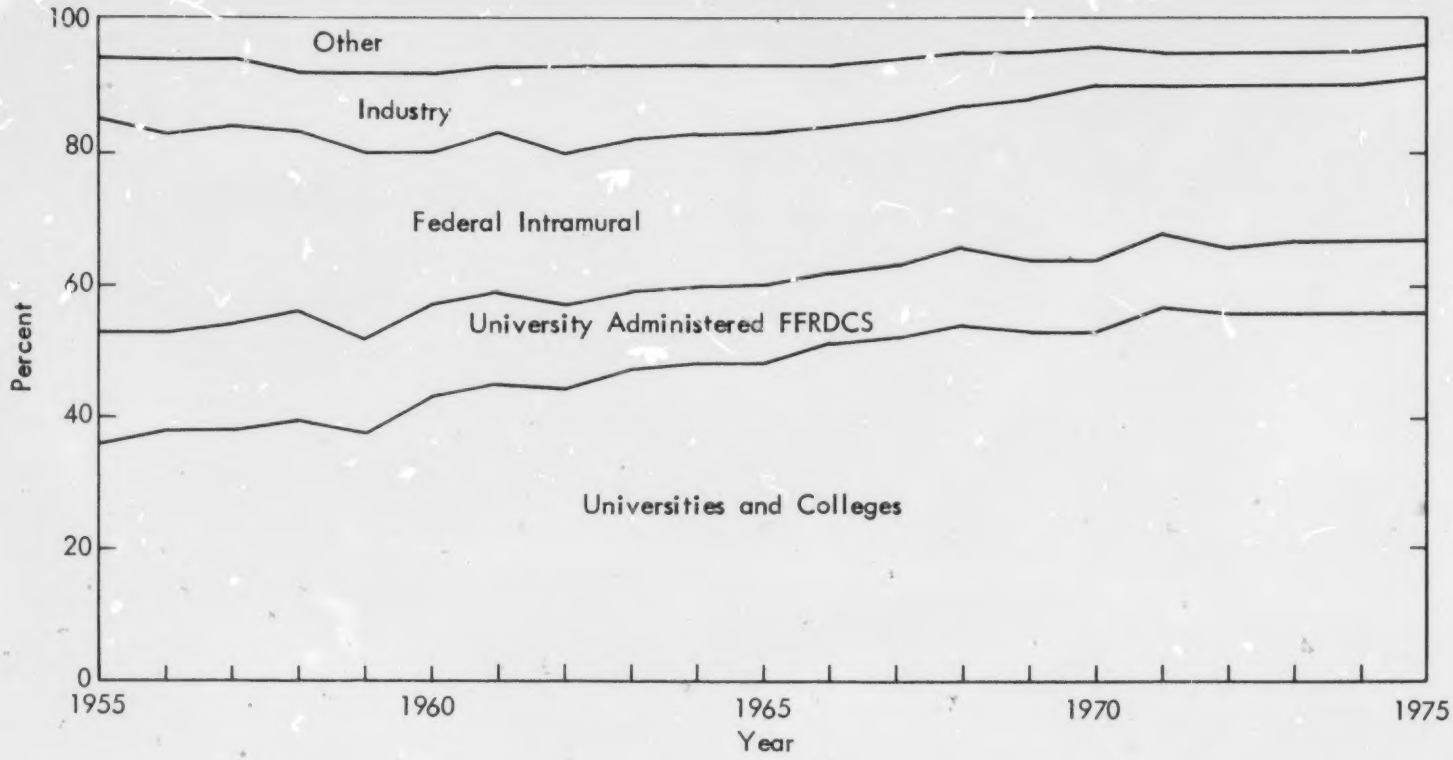
The growing federal share of university research support obviously meant that universities relied less and less on other sources of research funds. Although industry's support of R&D in universities more than doubled between 1953 and 1966, the fraction of total university R&D represented by these funds declined from 8 to 2 percent. Similarly, the share of university R&D supported by foundations and other nonprofit institutions declined from 11 percent in 1953 to 6 percent in 1966, although the dollar amounts increased by more than a factor of 4 during that period. Figure 2 shows a similar pattern for basic research. Although industry and private foundations had played significant roles in funding academic science prior to World War II, they together represented less than 10 percent of university research support by 1966.

FUNDS FOR UNIVERSITIES AND OTHER R&D PERFORMERS

Figures 3 through 6 show the distribution by performer of federal and total spending for basic research and R&D respectively, as derived from statistics published by the National Science Foundation.[1] It is easier to observe trends among performers by noting relative changes in shares of U.S. research spending than by comparing current or constant dollar amounts. Universities and colleges have steadily increased their percentage shares of spending in each research category. The year 1966 was the first in which the university sector reported

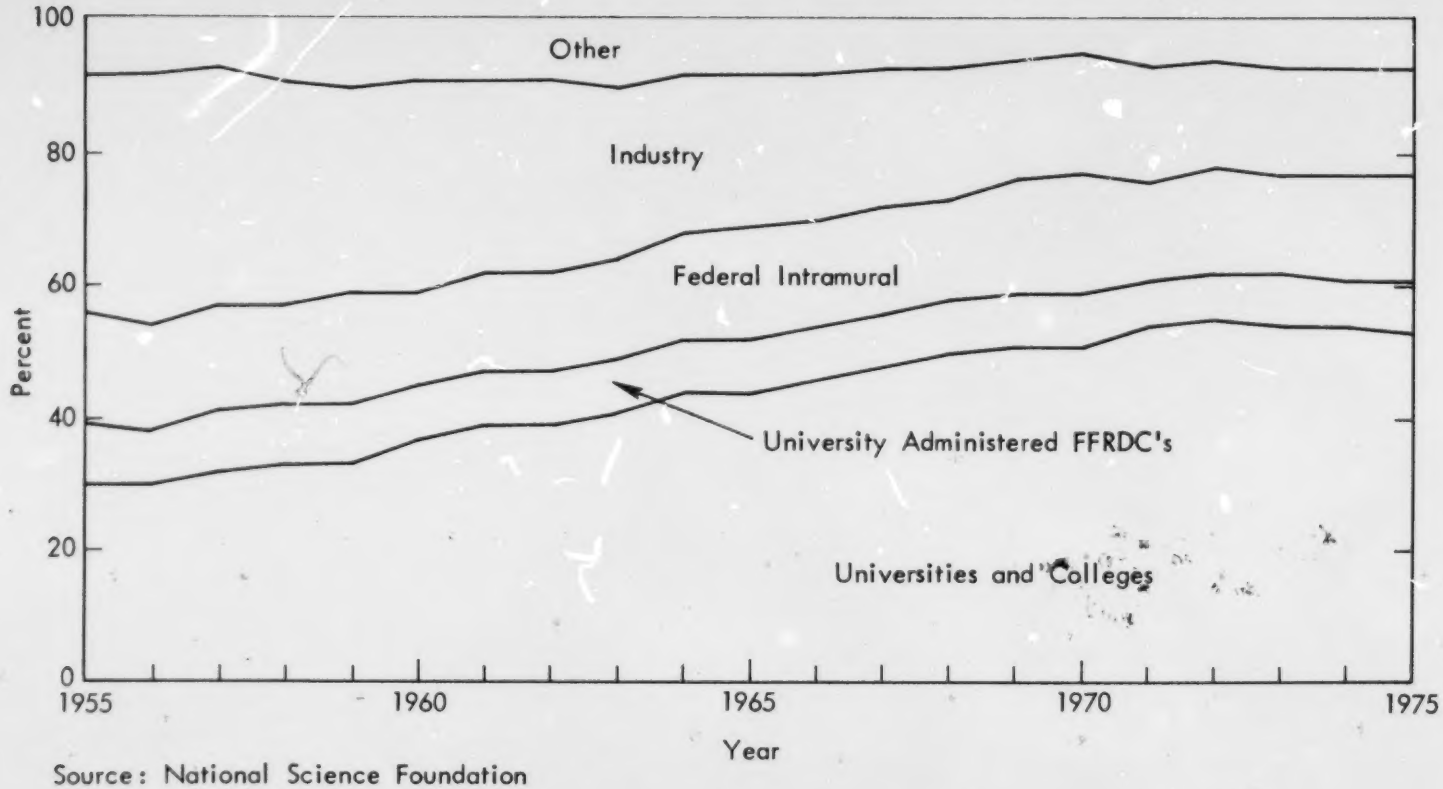
---

[1] National Science Foundation, *National Patterns of R&D Resources, 1953-1975*, NSF-75-307, 1975. These figures differ from those reported in the NSF annual series *Federal Funds for Research Development and Other Scientific Activities* in two principal ways. First, they are based on actual expenditures of federal funds reported by the R&D performers, rather than on obligations reported by the federal funding agencies (except for federal intramural laboratories, where obligations are used in both series). The performers' expenditure data differ from agency obligations both in timing (expenditures occur later than obligations) and in the divisions among basic research, applied research and development categories (e.g., industrial firms consistently report a lower ratio of basic to applied research performed with federal funds than do the agencies funding the research). Second, *National Patterns* combines calendar year data for industry and nonprofit institutions with federal fiscal year data for universities and federal intramural laboratories, while *Federal Funds* uses fiscal year data for all performers.



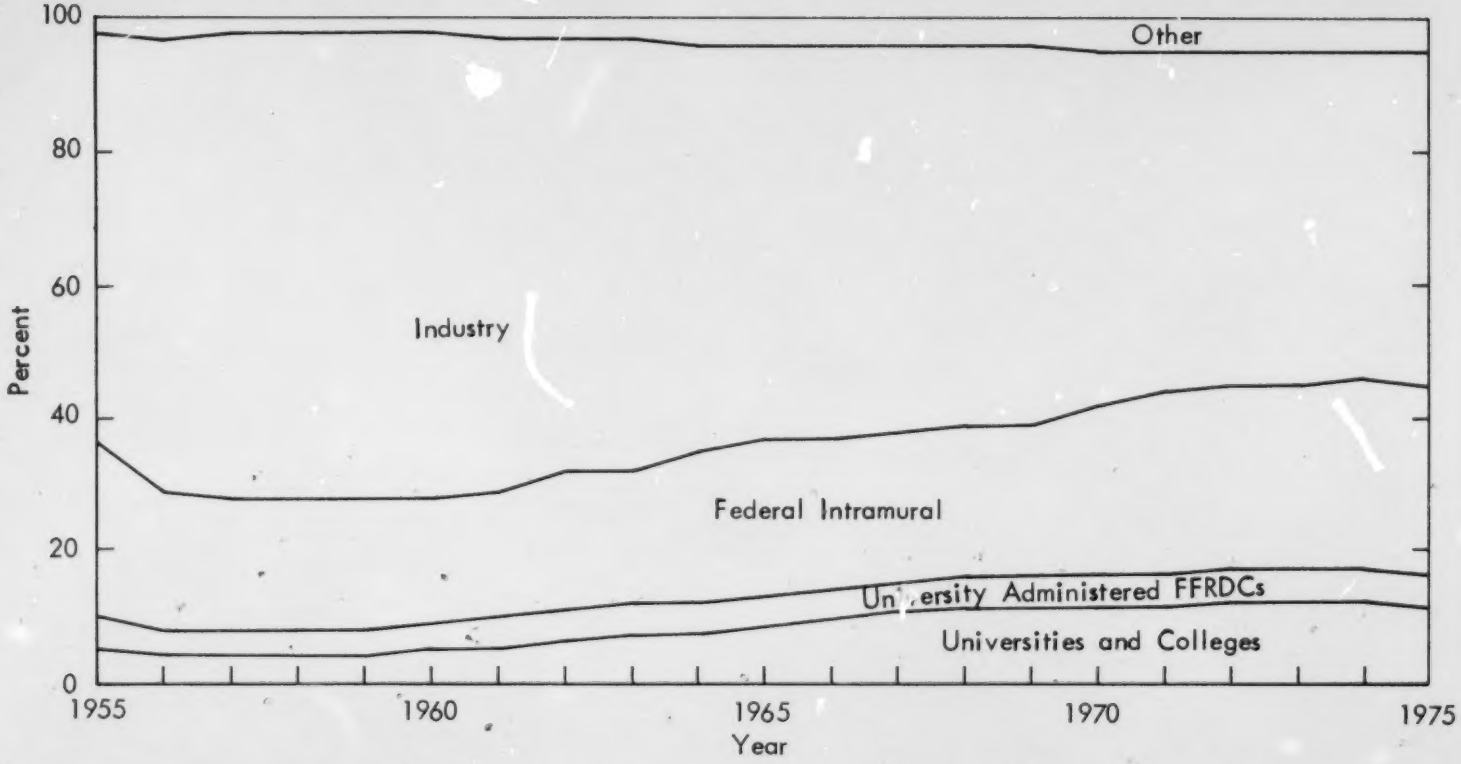
Source: National Science Foundation

Fig. 3 — Distribution of federal funds for basic research by performer, 1955-1975



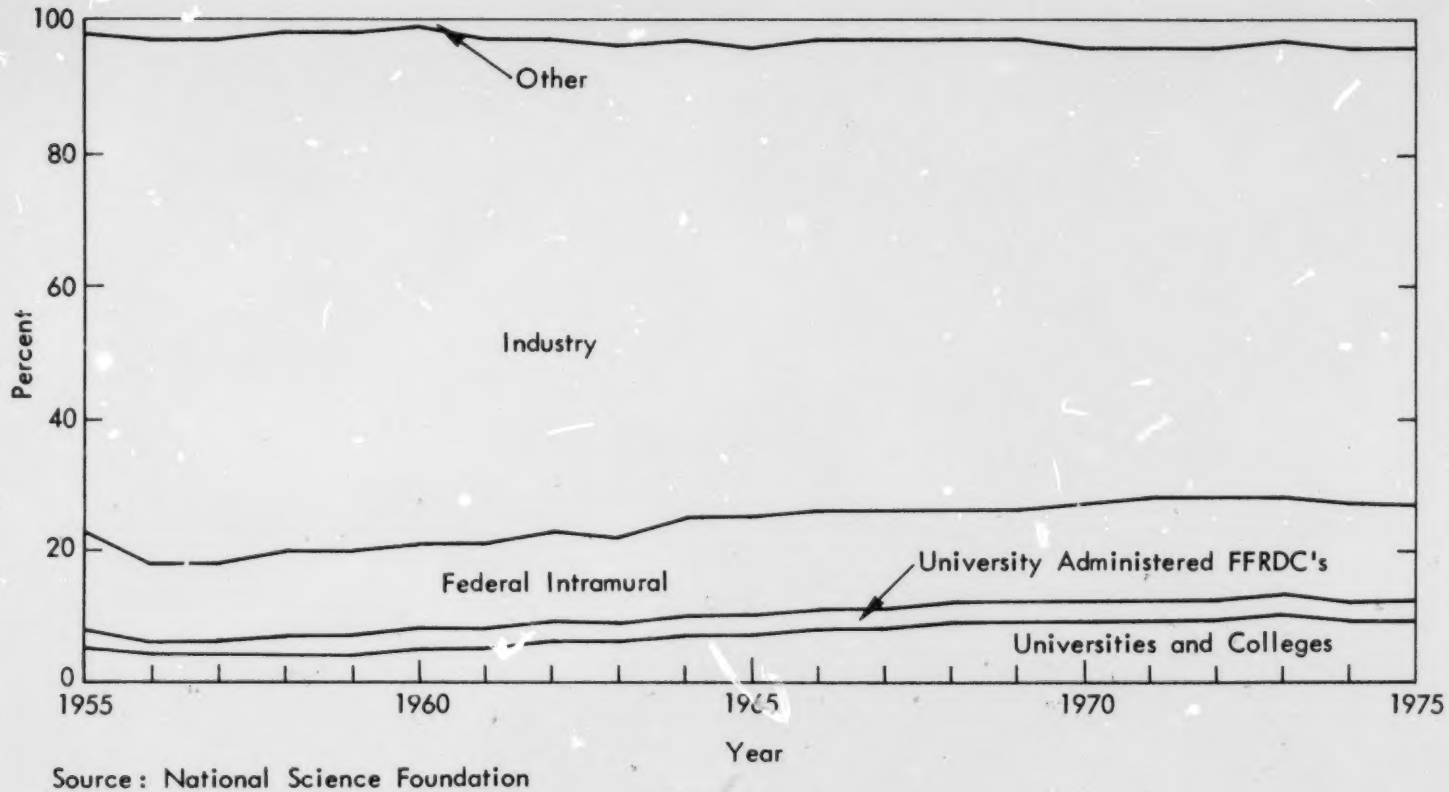
Source: National Science Foundation

Fig. 4—Distribution of total funds for basic research by performer, 1955 - 1975



Source: National Science Foundation

Fig. 5 — Distribution of federal R&D funds by performer, 1955-1975



Source: National Science Foundation

Fig. 6—Distribution of total R & D funds by performer, 1955 - 1975

spending more than half of all federal funds for basic research, up from 36 percent in 1955. When applied research and development are included, the university share of federal R&D spending is clearly smaller, but it increased from 5 to 9 percent between 1955 and 1966.

The rapid growth of federal funds for research also spawned new, research-based institutions. New government laboratories, industrial firms, and nonprofit research institutes were formed to perform government funded R&D, and a new class of federally funded research and development centers (FFRDCs) were created to perform research exclusively or principally for a federal agency. Department of Defense (DOD) agencies, the Atomic Energy Commission (AEC) -- now a part of the Energy Research and Development Administration (ERDA) -- and the National Aeronautics and Space Administration (NASA) have relied extensively on FFRDCs for R&D in their specific mission areas. The FFRDCs are administered by academic, industrial, or nonprofit institutions for the federal agency.

Among the well known, university managed FFRDCs are the Los Alamos and Livermore Laboratories operated by the University of California for ERDA/AEC; the Applied Physics Laboratory operated by Johns Hopkins University for the DOD; and the Jet Propulsion Laboratory operated by the California Institute of Technology for NASA. By the early 1950s the FFRDCs operated by universities had become the third largest recipient of federal funds for basic research, after universities and government laboratories. In 1966 university administered FFRDCs accounted for 10 percent of federal spending for basic research, and 5 percent of federal spending for all R&D.

The massive infusion of federal dollars since World War II thus had created a complex pattern of U.S. research performers by 1966. The university sector, predominantly supported by federal funds, had become the largest performer of basic research. Industry's share of basic research funds had dwindled from more than one-third (36%) in 1955 to less than one-quarter (22%) in 1966. The university-administered FFRDCs

and federal in-house laboratories maintained their shares of funds for basic research during that period. And a large number of new institutions had emerged in each sector. In twenty years the national commitment to research had created great U.S. strength in science and technology, but also an enormous number of institutional mouths to feed.

Changes in R&D Spending Among Performers Since 1966

The relative impact of the slowdown in U.S. research funding since the mid-1960s can be seen in Figures 3 through 6 as changes in the percentage shares accounted for by each group of research performers. A major observation is that universities have continued to increase their share of federal and total funds for basic research since 1966. As of 1975, universities and colleges accounted for 53 percent of total funds for basic research, compared with 46 percent in 1965 (Figure 4). To be sure, this increase was not as great as that in the preceding decade when the university share increased from 30 to 46 percent. Still, despite great fiscal pressures, universities managed to increase and consolidate their positions during the last decade as the predominant performers of basic research in the United States.

The increasing share of basic research performed by universities has come at the expense of industry. Total funds for basic research spent in industrial laboratories increased by less than 6 percent in current dollars between 1966 and 1975, resulting in a drop in the industrial sector's share from 22 percent in 1966 to 16 percent in 1975. Industry's decreasing share of basic research resulted from both an absolute drop in funding from the federal government, and a modest increase in industry's own funds for basic research that did not keep pace with the national average. While total U.S. spending for basic research increased 45 percent in current dollars between 1966 and 1975, industrial firms themselves spent only 16 percent more on basic research. Moreover, the percentage of industry's own R&D funds devoted to basic research declined from 6.3 percent in 1966 to 3.6 percent in 1975. The

implications for university/industry relations of industry's lower share of basic research spending are discussed in a later section.

The federal intramural laboratories, university administered FFRDCs, and other research performers have largely retained their shares of basic research spending -- as percentages both of total funds and of federal funds -- during the past decade.

The university gain in share of total R&D funds since 1966 (Figure 6) is much smaller, since universities typically perform less than 1 percent of the development function. The university share of total R&D spending grew from 8 to 9 percent during 1966-1975, while their share of federal R&D spending increased from 9 to 11 percent. The federal in-house laboratories increased their share of federal R&D spending more significantly -- from 23 to 29 percent -- during this period. Both these increases again reflect a decline of industry's share of federal R&D funds.

University-affiliated FFRDCs have by and large maintained their share of spending for both R&D and basic research since 1966, despite changes in the patterns of support for these centers that are described below. Similarly, the share represented by the independent research center and "other nonprofit institution" category have remained nearly constant.

The patterns of university research support have changed only moderately since 1966. With the slower growth of federal funds for university R&D, state government support and universities' own endowments have assumed more important roles. The federal government remains the principal funder of basic research in universities, but its share of support has slipped from 77 percent in 1966 to 70 percent in 1975.[1] A similar trend is seen in support for total university R&D. Industrial,

---

[1] Other components of federal support for colleges and universities, such as graduate student fellowships, have dropped far more dramatically during this period. See *Science Indicators 1974*, Report of the National Science Board, 1975, pp. 137-138.

foundation, and other support of university research has increased modestly since 1966, but together these sources constitute only 10 percent of the totals for university basic research or R&D.

Changes in Federal Agency Support of R&D Performers Since 1966

The changes in federal support of research performers shown in Figures 3 and 5 of course reflect shifts by individual federal agencies. Table 1 presents the percentage shares of R&D support, by agency, for each performer category in 1966 and 1975. Similar data for basic research are presented in Table 2.[1]

The university share of R&D funding from the Department of Defense, for example, has fallen from 4 to 2 percent during the past decade. Since DOD remains the largest agency supporter of research and development, this seemingly small percentage change represents a large shift in resources. If universities had maintained their same share of Defense R&D during this period, they would have received about $200 million more in 1975, or nearly 10 percent more than the total federal funding for university R&D in that year. Table 2 shows a similar but smaller drop in the DOD share of basic research contracts awarded to universities. The shift of Defense R&D resources away from universities is a direct result of policy decisions made by Congress and the Defense Department in the late 1960s, as discussed briefly below. Between 1966 and 1975 the DOD in-house laboratories were the chief beneficiaries of these shifts in allocation of R&D funds. Since 1975 DOD has changed its policy to increase the share of R&D funds for industry at the expense of the in-house laboratories.[2]

NASA also has decreased its dollar support of university R&D, from

---

[1] These figures are taken from the National Science Foundation series, *Federal Funds for Research, Development, and Other Scientific Activities*, Vol. XVI, pp. 112-113; Vol. XXIII, pp. 16-17, 44-45. The performer share totals are not the same as those shown in Figures 3 and 5 because of the different data series used. See Footnote 1 on page 7.

[2] *Physics Today*, September 1976, pp. 77-78.

Table 1

CHANGES IN FEDERAL AGENCY SUPPORT OF
RESEARCH AND DEVELOPMENT BY PERFORMER, 1966-1975

Department or Agency	Federal Agency R&D Obligations		Percent of Agency R&D Obligations									
			Universities		University-Affiliated FFRDCs		Federal Intramural		Industry[a]		Other	
	1966	1975	1966	1975	1966	1975	1966	1975	1966	1975	1966	1975
	(Millions of $)											
Defense	7,023	9,608	4	2	2	2	27	29	63	64	4	3
National Aeronautics & Space Admin.	5,050	3,071	2	3	2	3	17	33	78	60	1	1
Health, Education and Welfare	1,014	2,233	53	52	-	-	18	20	4	5	25	23
Atomic Energy Commission	1,212	1,704	7	6	32	33	2	1	55	57	4	3
National Science Foundation	227	653	79	78	7	6	6	2	1	7	7	7
Interior	143	557	14	8	-	-	66	39	10	45	10	8
Agriculture	235	406	26	24	-	-	70	73	1	-	3	3
Transportation	172	397	1	6	-	1	24	18	73	55	2	20
Environmental Protection Agency	[b]	343	[b]	6	[b]	-	[b]	25	[b]	59	[b]	10
Commerce	55	263	7	10	-	-	76	53	16	17	1	20
Others	173	362	18	10	-	-	43	49	17	13	22	28
Total	15,304	19,597	9	12	4	5	21	27	61	51	5	5

[a] Includes FFRDCs administered by industrial firms.

[b] Agency did not exist in 1966.

Source: National Science Foundation, *Federal Funds for Research, Development, and Other Scientific Activities*, Vol. XVI, 1967, pp. 112-113, XXIII; XXIII Detailed Statistical Tables, 1974, pp. 16-17.

Table 2

CHANGES IN FEDERAL AGENCY SUPPORT OF BASIC RESEARCH,
BY PERFORMER, 1966-1975

Agency	Basic Research Obligations		Percent of Obligations for Basic Research									
			Universities		University-Affiliated FRDCs		Federal Intramural		Industry[a]		Other	
	1966	1975	1966	1975	1966	1975	1966	1975	1966	1975	1966	1975
	(Millions of $)											
Defense	262	257	50	42	1	-	32	41	10	13	7	4
National Aeronautics & Space Admin.	559	632	17	6	7	8	28	36	47	49	1	1
Health, Education and Welfare	326	544	62	73	-	-	18	13	-	-	20	14
Atomic Energy Commission	281	325	27	22	56	64	2	-	11	13	4	1
National Science Foundation	223	509	80	86	7	6	5	1	1	3	7	4
Interior	51	109	24	15	-	-	67	80	4	3	5	2
Agriculture	94	157	27	25	-	-	66	71	1	-	6	4
Others	48	66	16	26	-	-	78	68	4	2	2	4
Total	1,844	2,599	40	43	12	11	24	25	18	16	6	5

[a] Source: National Science Foundation, *Federal Funds for Research, Development, and Other Scientific Activities*, Vol. XVI, 1967, 112-113, XXIII; XXIII Detailed Statistical Tables, 1974, pp. 16-17.

$117 million in 1966 to $83 million in 1975. This drop, however, reflects the sharp cuts in NASA programs after the manned lunar landing, rather than a shift away from support of university R&D. Universities in fact received a larger share of NASA R&D spending in 1975 than in 1966, although a significantly smaller share of NASA funds for basic research. The end of the Apollo program principally resulted in the termination of many industrial contracts, with a shift of NASA R&D shares from industry to in-house NASA laboratories.

The three other principal patrons of university R&D - the Department of Health, Education and Welfare (HEW), the National Science Foundation, and the Atomic Energy Commission - have not significantly changed their percentages of R&D support flowing to universities during the past decade. HEW devotes a slightly larger share of its R&D funding to in-house research, but the university share only declined from 53 to 52 percent. The National Science Foundation, despite an increasing emphasis on applied research through the RANN program, continues to devote nearly the same share to university R&D in 1975 as in 1966. The principal impact of the RANN program on research performers appears to be the increased support of R&D performed in industry. Similar changes anticipated in energy R&D do not show up in the 1975 figures that predate the formation of ERDA.

One notes from Table 1 that the new emphasis on civilian R&D among other federal agencies[1] had not significantly affected university research support by 1975. The Department of Transportation, the Department of Commerce, the Department of Justice, the Department of Labor, and the Environmental Protection Agency each increased the university components of their R&D programs. Because these programs are still relatively small, however, they have had relatively little impact on the overall flow of federal R&D dollars to universities.

The most notable change in performer emphasis in the civilian R&D programs has been to increase the shares of R&D support awarded to state

---

[1] *Science Indicators*, op. cit., pp. 40-43.

and local government agencies, particularly in transportation, economic development, criminal justice, and air and water pollution control. According to NSF statistics, state and local governments received $228 million in federal research funds in 1975. The bulk of these funds are then awarded to other research performers, including universities; but their precise distribution remains undocumented. Spriesterbach et al reported that for ten selected universities, state funds for sponsored research increased 65 percent between 1970 and 1973.[1] This is undoubtedly a more rapid increase than for the university sector as a whole, but it is clear that state governments are playing an increasingly important role in the funding of university research.

All in all, the increased university share of federal R&D support during the 1966-1975 period has resulted more from increases in the R&D budgets in HEW and NSF, the two agencies that emphasize university R&D most, than from shifts of resources away from other research performers. In basic research, increased shares to universities from HEW and NSF have outweighed the decreased university shares from DOD, NASA, and AEC.

The university share of federal R&D support seems unlikely to increase in the next decade as it has in the past, particularly if the federal government places greater emphasis on R&D directed toward the civilian economy. Large R&D programs in energy, environmental protection, transportation, and other civilian sectors are more likely to increase industry's share of federal R&D expenditures. ERDA, for example, is committed to large scale development and commercial demonstration of new energy technologies in partnership with industry. State and local governments may also be expected to increase their R&D spending as recipients of federal revenue sharing or direct R&D support, but some of these funds will in turn be spent in the university sector.

Thus, the major conclusion from an examination of funding patterns among research performers during the past ten years is that universities

---

[1] Spriesterbach, D. C., Margery E. Hoppin, and John McCrone, "University Research and the New Federalism," *Science*, Vol. 186, October 25, 1974, pp. 324-327.

have fared remarkably well. Fears that campus disorders and related university crises in the late 1960s and early 1970s would turn Congress away from supporting research in universities have, fortunately, not been realized.[1] The university sector has increased its share of total spending for R&D and basic research during the past decade, as well as its share of federal funds. That trend is unlikely to continue into the future; not because of a diminished federal interest in supporting university research, but because new federal priorities will imply larger commitments to large-scale development and demonstration programs carried out by industry and other research performers.

CHANGING RELATIONSHIPS BETWEEN UNIVERSITIES AND OTHER R&D PERFORMERS

Behind the financial statistics, the past ten years have seen the paradox of universities moving toward both greater cooperation and more competition with other research institutions. Since the demand for new research Ph.D.s diminished in the late 1960s, colleges and universities have been urged to be more responsive to the direct manpower needs of industry and government. Many voices, within academe as well as industry, have called for universities to redress their neglect of industrial research problems in the era when federal research funds were flowing easily. The call for "relevance" in university research also has implied a need for closer associations with government, industry, and the nonprofit sector in addressing problems perceived to be of national importance. But on the other hand, it is clear that competition for research funds between universities and other research performers has become far more intense in the last decade than when resources were growing handsomely in the 1950s and 1960s. The competition is seen in trends such as:

---

[1]For example, see Nichols, Rodney W., "Mission Oriented R&D," *Science*, April 2, 1971, pp. 29-37; and Orlans, H., *The Nonprofit Research Institute*, 1972, p. 141.

- o Severed or loosened ties between universities and contract research centers
- o Changes in university administered FFRDCs
- o Growth of project research institutes run by university faculty
- o University competition with FFRDCs and independent research centers for applied and interdisciplinary research funds
- o University competition with government in-house laboratories

These trends will be reviewed below, followed by a discussion of university relationships with industrial firms.

University Contract Research Centers: Moving Classified Research Off Campus

University administered contract research centers, nearly all of which performed some classified research sponsored by defense agencies, became caught up in the wave of anti-military protests by students and faculty during the late 1960s. Like other aspects of academic administration, the treatment of classified research was never particularly tidy or consistent among the nation's universities. A classified research project was often the direct outgrowth of a faculty member's consulting for DOD or serving on a defense agency panel. Administering classified research in an academic environment raised not only problems of security and restricted access facilities, but also questions of how such work would relate to traditional scholarship. While universities differed in their attitudes and approaches, a common solution was to establish a separate laboratory or center for classified contracts. Some centers were included as integral units of the university, such as the Instrumentation Laboratory at MIT and the Willow Run Laboratories at the University of Michigan; some were established as FFRDCs, such as the MIT Lincoln Laboratory and the Applied Physics Laboratory operated by Johns Hopkins; and some were incorporated as separate institutions accepting both government and private research contracts, such as the Stanford Research Institute and the Cornell Aeronautical Laboratory.[1]

[1] For an excellent account of the rise of university contract research centers, see Orlans, Harold, *The Nonprofit Research Institute*, New York, McGraw-Hill, 1972.

Whatever their administrative arrangements with the sponsoring university, contract centers became one focus of student protests against performing classified research in an academic environment. Contract centers were targets of picketing, sit-ins, and increasingly more violent protests, including the bombing of the Army Mathematics Research Center at the University of Wisconsin in 1970 that killed a postdoctoral student working on an unrelated (and unclassified) research project in another field. Moreover, passage of the Mansfield Amendment in 1969 restricted DOD support to research with "a direct and apparent relationship to a specific military function or operation."[1] This meant that academic contract research centers could do less defense-sponsored basic research that was particularly attractive to university faculty members.

As a result, a number of universities decided to eliminate on-campus classified research, and in the process some cut loose their contract research centers. Stanford University's severance of ties with the Stanford Research Institute (SRI) in 1970 was the largest and most publicized of these spinoffs. But there were others. A year earlier, the staff of the Stanford University Applied Electronics Laboratory transferred to SRI. In 1967 Columbia University converted its Electronics Research Laboratory to an independent, non-profit institution renamed the Riverside Research Institute. The MIT Instrumentation Laboratory was separated from the university in 1973, renamed the Charles Stark Draper Laboratory, and reoriented from military guidance and control projects toward space, air transportation, and related civilian research.[2] The University of Michigan converted its Willow Run Laboratories in 1972 to an independent, nonprofit institute emphasizing

---

[1] Public Law 91-121, Section 203, quoted in Nichols, op cit., p. 29.

[2] Preceding the nation's Bicentennial celebration by three years, the Charles Stark Draper Laboratory issued its own *Declaration* of 1 July 1973: "When in the Course of human Events it becomes necessary for two Institutions to revise the Bonds which have connected them... It is entirely fitting that this Separation take place and it is likewise fitting for us to solemnly Publish and Declare, That the Charles Stark Draper Laboratory is, and of Right ought to be a free and independent institution, with full Power to contract Alliances, establish Commerce and do all other Acts and Things which Independent Laboratories may of right do...."

environmental research. Only a few contract research centers with annual expenditures of $1 million or more, such as the Denver Research Institute, continue to operate as integral parts of their sponsoring universities.

A particularly interesting case is that of the Cornell Aeronautical Laboratory (CAL), which was operated as a division of Cornell University although located 100 miles away near Buffalo. The CAL was not classified as an FFRDC, since it accepted contracts from private as well as government sponsors, but much of its research was classified. After student protests against classified work at CAL, the university tried to sell the Laboratory to a private firm in 1969. However, the State of New York, supported by many of the CAL employees, successfully sued to block the sale. Stymied in its attempt to sell the laboratory, Cornell University agreed to its conversion to a for-profit status. Renamed Calspan, the laboratory now operates as a profit-seeking firm, but still a wholly owned subsidiary of Cornell University.

University divestiture has generally enabled contract research centers to broaden their R&D interests and to diversify their base of contract support. The effect on universities has been to establish a more explicit arm's-length relationship between faculty and the centers, as well as to create potential competitors for applied research support.[1]

In many cases the separation seems to be a natural consequence of a center's growth and maturity as much as a result of the classified research controversy. Universities took on responsibility for creating defense-oriented research capabilities at a time when they had unique talents and resources to do so. By the late 1960s, more than twenty years after the end of World War II, many of these centers had become large, relatively stable institutions with interests quite different from those of their academic sponsors. The university's advantages of receiving management and overhead fees from contract research, as well as providing research opportunities and specialized facilities for faculty

---

[1] Orlans, op cit., pp. 126-132.

members, were often outweighed by the disadvantages of managing an organization whose objectives were increasingly divergent from the university's principal roles of teaching and basic research. From the contract research center's standpoint, the university affiliation brought prestige and greater access to faculty members and graduate students, but also the disadvantages of dealing with a university administration that often constrained the research center's prospects for growth. Consequently, separation of the contract center from the university has often been in the best interests of both institutions.

University Administered FFRDCs

The storm against classified research also turned against university administered FFRDCs sponsored by the Defense Department. As shown in Table 3, five of the eight university managed, defense sponsored FFRDCs in 1966 had by 1975 been phased out or transferred to other administrators. Only the Applied Physics Laboratory operated by Johns Hopkins University, the Applied Research Laboratory managed by Pennsylvania State University, and MIT's Lincoln Laboratory remained university affiliated throughout this period. Management of another defense sponsored FFRDC, the Center for Naval Analyses, was transferred in 1967 from the Franklin Institute (an independent nonprofit institute) to the University of Rochester. The CNA is located in Northern Virginia, several hundred miles away from the University of Rochester campus, which may have sheltered it from some of the student protest that arose after the transfer.

For different reasons, HEW's attempt to establish university administered FFRDCs for educational research proved unsuccessful. These centers were created toward the end of the R&D boom period by an agency that, unlike Defense and AEC, had little experience in contracting for mission-oriented research. Faced with growing stringency in research budgets, a change of Administration, and an often hostile Congress, HEW phased out its university administered, educational research FFRDCs or transferred them to other institutional managers in the early 1970s.

Table 3

UNIVERSITY-AFFILIATED FFRDCs, 1966-1975

Federal Agency Sponsor	FFRDC	University Administrator	Change in FFRDC Status, 1966 - 1975
Atomic Energy Commission (Now Energy Research and Development Administration)	Ames Laboratory	Iowa State University	
	Argonne National Laboratory	University of Chicago and Argonne Universities Assoc.	
	Brookhaven National Laboratory	Associated Universities, Inc.	
	Cambridge Electron Accelerator	Harvard University	Phased out 1973
	Fermi National Accelerator Laboratory	University Research Associates	Established 1968
	Lawrence Berkeley Laboratory	University of California	
	Lawrence Livermore Laboratory	University of California	
	Los Alamos Scientific Laboratory	University of California	
	Oak Ridge Associated Laboratory	Oak Ridge Associated Universities	
	Princeton-Pennsylvania Accelerator	Princeton University and University of Pennsylvania	Phased out 1971
	Plasma Physics Laboratory	Princeton University	
	Stanford Linear Accelerator Center	Stanford University	
Department of Defense	Applied Physics Laboratory	Johns Hopkins University	
	Applied Physics Laboratory	University of Washington	Phased out 1974
	Applied Research Laboratory	Pennsylvania State University	
	Army Mathematics Research Center	University of Wisconsin	Phased out 1970
	Center for Naval Analyses	University of Rochester	Became university administered 1964
	Center for Research in Social Systems	American University	Phased out 1970
	Human Resources Research Organization	George Washington University	Changed to nonprofit administered 1969
	Hudson Laboratory	Columbia University	Phased out 1969
	Lincoln Laboratory	Massachusetts Institute of Technology	
National Aeronautics and Space Administration	Jet Propulsion Laboratory	California Institute of Technology	
	Space Radiation Effects Laboratory	College of William and Mary	
National Science Foundation	Cerro Tololo Inter-American Observatory	~~Association of Universities for~~ Research in Astronomy, Inc.	
	Kitt Peak National Observatory	Association of Universities for Research in Astronomy, Inc.	
	National Astronomy and Ionospheric Center	Cornell University	Established 1970
	National Center for Atmospheric Research	University Corporation for Atmospheric Research	
	National Radio Astronomy Observatory	Associated Universities, Inc.	
Department of Health, Education and Welfare	Center for the Advanced Study of Education Administration	University of Oregon	Phased out 1972
	Center for Research and Development in Educational Differences	Harvard University	Phased out 1967
	Center for Research and Development in Higher Education	University of California	Phased out 1972
	Center for Research and Development for Learning and Re-education	University of Wisconsin	Phased out 1972
	Center for the Study of the Evaluation of Instructional Program	University of California	Phased out 1972
	Center for the Study of Social Organization of Schools and the Learning Process	Johns Hopkins University	Phased out 1972
	Coordination Center for the National Program in Early Childhood Education	University of Illinois	Phased out 1970
	Learning Research & Development Center	University of Pittsburgh	Phased out 1972
	Research and Development Center in Educational Stimulation	University of Georgia	Phased out 1970
	Research and Development Center in Teacher Education	University of Texas	Phased out 1972
	Stanford Center for Research & Development in Teaching	Stanford University	Phased out 1972

The university-affiliated FFRDCs supported by NASA and AEC/ERDA have been more stable. NASA's Jet Propulsion Laboratory and the AEC/ERDA multiprogram national laboratories have diversified from space and atomic energy research and basic science to applied work directed toward energy, the environment, and other national civilian priorities. Five of the eight AEC/ERDA multiprogram FFRDCs -- Argonne, Brookhaven, Lawrence Berkeley, Lawrence Livermore, and Los Alamos -- are university administered, while two (Oak Ridge and Sandia) are managed by industrial firms and one (Pacific Northwest) by a nonprofit institution. With the formation of the Energy Research and Development Administration in 1975, these FFRDCs have been called on to broaden their efforts in support of energy development and demonstration programs. This will tend to move the multiprogram national laboratories toward closer working relationships with industry, since private sector firms are intended to be the ultimate users of the energy technologies developed by ERDA. Whether developing such ties with industry will prove difficult for university administered FFRDCs, or require changes in their administrative structures, remains to be seen.

The remaining university administered FFRDCs supported by AEC/ERDA provide specialized research facilities for high energy physics, plasma physics, and other areas of nuclear science. The increasing costs of high energy physics required the closing of the Princeton-Penn Accelerator and the Cambridge Electron Accelerator in order to free funds for the new Fermi National Accelerator Laboratory. The National Science Foundation also supports five national research facilities in astronomy and atmospheric science as university-managed FFRDCs, as listed in Table 3. One of these facilities, the National Astronomy and Ionospheric Center in Puerto Rico, was picked up from the Defense Department in 1970 as a result of DOD's shedding of some basic research support after passage of the Mansfield Amendment.

Establishing new national research centers seems likely in the future as more fields of science require large capital investments in research facilities with full time staff to operate them. Frontier research in

many fields will be conducted by user groups of scientists from different institutions sharing specialized facilities, as is done today in high energy physics, astronomy, and oceanography.[1] Biological and medical research increasingly requires special cell cultures or experimental animals maintained in centralized laboratories. And social scientists see a parallel need to develop common data bases available to users from many institutions. Although this trend toward sharing specialized research facilities already seems well established, available data are inadequate to document its full extent. In the future we are likely to see some research centers now managed by a single university converted to the university managed FFRDC category, as well as the creation of new national facilities for basic science.

Project Research Institutes

While there is more than a little fuzziness in the boundaries between university contract research centers and FFRDCs, they both differ from institutions incorporated to perform research on specific grants and contracts. Such "project institutes" are, in Harold Orlans' words, "the most motley and volatile type of institute..., [created] most frequently as ventures of faculty who, dissatisfied with the constraints of projects administered by their institutions, may be adventurous in their spare time while retaining the security of tenure."[2] A project institute may be little more than the extension of a professor's consulting practice, perhaps incorporated to avoid the low daily consulting rates paid by government agencies. Or it may develop a sizable staff of its own. The Center for Policy Research, among the regularly cited examples of a project institute, noted in its review of its first five years of operation:

---

[1] Albert Crewe and Frank Press, among others, have proposed that the federal government give greater emphasis to the support of national research facilities. Crewe, Albert V., "Science on a Regional Scale," in Boyd R. Keenan (ed.), *Science and the University*, Columbia University Press, New York 1966; and Press, Frank, "New Arrangements for Science in the Universities," *Science*, July 18, 1975, p. 177.

[2] Orlans, op. cit., pp. 42-43.

> "While the Center initially sought part-time senior staff (i.e., professors who corbine their university affiliation with summer work or limited consulting work at the Center), in recent years, full time researchers have been added."[1]

From a professor's point of view, a project institute can bring added income, the flexibility to do work that the university might not approve, and freedom from paying university overhead while still maintaining access to the university library, computers, and other facilities. From the government agency's standpoint, contracting with a project institute can mean faster research results at lower cost. Some professors reportedly have been encouraged to submit proposals through a project institute rather than through their university in order to meet an agency's time and budget constraints.

Project institutes seem an inevitable and probably desirable part of a dynamic research system with multiple funding sources and performers. They are the research performers most responsive to new policy directions and changing research priorities of government agencies. And their potential for abuse -- in terms of overcommitted faculty or unreimbursed use of university facilities -- seems largely controllable by sensible university regulations. To date university administrators have generally chosen not to fight against the formation of project institutes by senior, tenured faculty.[2]

Anecdotally at least, project institutes headed by part-time faculty members seem to be proliferating rapidly. However, no data are available on their numbers, funding levels, or importance as research performers. While recent interviews with federal officials, faculty members, and university administrators suggest that project institutes have become a larger and clearly distinguishable category of research performers in the past ten years, any more coherent description of their size, status, and

---

[1] Castleman, Nancy and Pamela Doty, *Center for Policy Research: The First Five Years, 1968-73*, p. 6.

[2] A public university may have less incentive than a private university to oppose project institutes, since overhead recovered from federal grants must be returned to the state.

role in the U.S. research system must await the results of a more systematic survey.

Competition Among Research Performers

Virtually everyone agrees that universities face greater competition for research funds today than a decade ago. The competition is principally among the universities themselves, although university administrators frequently cite competitive pressures from nonprofit institutes and in-house government laboratories. Many believe that federal intramural research is taking an expanded share of government R&D dollars. As research budgets contract, the argument goes, federal agencies tend to favor their own in-house laboratories over universities and other R&D performers. Thus the 1975 DOD Laboratory Utilization Study reported:

> "We found that the in-house laboratory share of the DOD budget has increased by about 15% in the past six years. No compelling reason for increasing the laboratories' budget was found. To the contrary, there was some evidence of the laboratories being under strain to stay fully employed. Based upon some Service studies and personal visits to most of the laboratories, it is believed that a modest reduction in the size of the in-house laboratories...could produce some savings and eliminate some excessive competition."[1]

Similarly, the 1975 report of the Field and Laboratory Utilization Study Group to ERDA stated:

> "There is the need, however, to address the beliefs, real or perceived, on the part of some members of industry and universities, that the [ERDA] laboratories do not make sufficient use of out-of-house research and development resources, are self-perpetuating, and, in fact, compete with them for limited federal research and development funds."[2]

---

[1] Allen, J. L. et al., *The DOD Laboratory Utilization Study*, April 1975, pp. xiii-xiv.

[2] *Report of the Field and Laboratory Utilization Study Group*, U.S. Energy Research and Development Administration, December 1975, p. 32.

Insofar as universities are concerned, the aggregate data presented in Figures 3 and 5 do not support this contention. Federal in-house laboratories have increased their share of federal R&D spending more than the university sector, but both have grown since 1966. In the distribution of federal spending for basic research, the university share has grown slightly faster than that of the intramural laboratories during the past decade. The largest relative gains for the federal intramural sector between 1966 and 1975 have come in the development category, at the expense of industrial firms. This trend has been reversed since 1975 through explicit policy decisions by DOD and other agencies to limit in-house R&D.[1]

However, the questions surrounding federal in-house R&D really pertain to research quality more than quantity. As a recent National Academy of Sciences report (the Pound Report) noted with respect to the U.S. Department of Agriculture (USDA), few government agencies encourage peer review of their in-house research which consequently may be below the standard of work performed at other institutions.[2] Maintaining high quality research in government laboratories is a perennial problem that receives more attention in times of financial stringency. Regular, high level review of agency intramural R&D in relation to work going on in other institutions -- perhaps by the newly resurrected Office of Science and Technology Policy -- seems clearly advisable for a variety of reasons, not only to promote "fair" competition among research performers.

It is in applied research that universities now face the most serious competition from other institutions. Most "interdisciplinary" and policy oriented research falls into this category. Universities, with their traditional departmental autonomy and incentive structure organized along disciplinary lines, have not moved easily into the interdisciplinary

---

[1] *Physics Today*, op. cit.

[2] National Academy of Sciences, *Report of the Committee Advisory to the U.S. Department of Agriculture*, 1973; similar criticism is contained in Mayer, Andre and Joan Mayer, "Agriculture, The Island Empire," *Daedalus*, Summer 1974, pp. 83-96.

research arena. And, once there, universities find themselves in competition with a number of research institutions - profit-seeking, nonprofit, and FFRDCs - that specialize in this kind of work.[1] Consequently, it is not surprising that academic institutions received only 50 percent of the applied research funds awarded by the National Science Foundation in 1975, compared with 86 percent of NSF grant monies for basic research.[2] Given the large number and variety of institutions capable of conducting applied or policy-oriented research, one does not really expect to see universities perform a significantly greater share of this work in the future.

UNIVERSITY RELATIONSHIPS WITH INDUSTRY

The academic and industrial research communities have consistently held ambivalent attitudes toward each other. On the one hand, certain interactions were natural and desirable: university faculty as industrial consultants, industrial hiring of university graduates, and so forth. Engineering faculty members have for many years received industrial support for research, worked in industrial laboratories during the summer, and sent graduate students to write dissertations in industry. Industrial firms have valued university contacts as windows on new developments, as well as sources of expertise unavailable within the firm.[3] For many firms, a small investment in university research

---

[1]For a comparative discussion of interdisciplinary research in universities, independent research centers, and government, see Nilles, Jack M., "Interdisciplinary Policy Research and the Universities"; Baer, W. S., "Interdisciplinary Policy Research in Independent Research Centers;" Polishuk, P., "Problems in Interdisciplinary Policy Research and Management in Government," *IEEE Transactions on Engineering Management*, May 1976, pp. 74-84, 92-100.

[2]National Science Foundation, *Federal Funds for Research, Development, and Other Scientific Activities*, Vol. XXIII, Detailed Statistical Tables, 1974, p. 47, 67.

[3]Or in the words of one industrial research manager, the Director of the Rockwell International Science Center: "There are a lot of advantages...to working with universities....One is the outstanding creative talents. That does not mean we do not have them in industry; it just means our people get numb sooner." T. L. Loucks, "University-Industry Joint Projects: An Industrial View," *Journal of the Society of Research Administrators*, Spring, 1974, p. 35.

support or graduate student fellowships has been a very cost-effective way of extending their own research capabilities and obtaining early knowledge of new results.

On the other hand, academics and industrialists have traditionally been suspicious of each other's motives and modes of operation. The condescending attitude of the professor toward practical matters or the commercial exploitation of knowledge, and the businessman's disdain for ivory tower research are familiar stereotypes.

Studies and recommendations abound concerning how to "improve" university-industry relationships through joint research projects or other collaborative efforts. Yet the obstacles to closer collaboration are very real. Discussions of the issue consistently cite institutional differences in research objectives: differences in the timeframe for obtaining and reporting results; differences regarding publication and patent policies; and mutual misunderstandings exacerbated by a lack of communication.[1] The publication and patent problem is a particularly thorny one. Professors obviously want freedom to publish their research results. But a company sponsoring a joint research project wants to benefit from the information before its competitors can. Telling an industrial research manager that his firm cannot have proprietary rights to research it sponsors at a university is like telling the university professor that he can only publish his results anonymously. Neither approach is likely to generate much enthusiasm for joint research projects.

Weakened Bonds: 1945-1970

Since these barriers to university-industry cooperation are hardly new, it is reasonable to ask whether the coupling problems have indeed

---

[1] See, for example, *Industry, Science and the Universities*, Confederation of British Industry, London, 1970, pp. 56-57, 88-89; Libsch, Joseph F., "The Role of the Small, High Technology University," *Research Management*, May 1976, pp. 28-31. Most of the published literature on this topic consists of personal statements and calls for "better communications" between the two sectors; a thoughtful and perceptive exception is Roy, Rustum, "University-Industry Interaction Patterns," *Science*, December 1, 1972, pp. 955-960. Additional efforts to develop an analytic framework for and quantitative data about U.S. university-industry interactions would seem highly useful.

worsened in recent years. While hard evidence is lacking,[1] there are reasons to believe that the links between universities and industry weakened in the two decades following World War II and approached their nadir in the early 1970s. The principal factors behind the decline appear to have been:

- o the separation of academic research from perceived industrial needs;
- o a decreased interest in industrial research among Ph.D.s and other graduates;
- o a relative decline in industry's support of basic research.

1. Separation of academic research from industry.

The era of rapid growth of federal funds for academic research gave universities less incentive to maintain or strengthen their ties with industrial firms. Moreover, support from defense and space agencies drew university research toward "high technology" and away from other industrial problems. This was especially true of university engineering departments. Engineering faculty engaged in research on space vehicles or advanced radar systems found little in common with conventional industrial engineering. Defense and space research focused on *performance* improvements -- continually pushing the state-of-the-art -- while other industrial R&D continued to emphasize *cost* improvements as well. There was no question about which was the more interesting direction for university engineering research to pursue.

Some close working relationships developed between aerospace firms and university engineering departments in the 1950s and 1960s; and many new high technology firms were spawned from academic research, with

---

[1] Attempts to chart university-industry relationships by observing the number of ideas or "events" in the university sector that have led to industrial innovation seem of little help. The relative importance of the university-initiated ideas depends principally on the timeframe used in the analysis, as a comparison of the Hindsight and Traces studies indicates. The longer the time horizon, the more likely the innovation will have some university roots.

professors as corporate directors or entrepreneurs. The high technology companies surrounding Harvard and MIT on Route 128, and the new electronics and instrument firms near Stanford, became models for other parts of the nation and the world. But with the end of the Apollo program, the decline of defense support for university research, and the shift in national priorities toward energy, the environment and related problems demanding cost as well as performance improvements, university engineering faculties often found themselves unfamiliar with the relevant industrial firms that had not ventured into high technology.

This was not true of all university engineering, of course. Many academic programs in materials science, for example, while conducting research in exotic materials for space and defense applications, kept their ties with other manufacturing industries as well. But such efforts seemed more the exception than the rule during the 1950s and 1960s, especially at the most prestigious universities.

2. Lessened student interest in industrial research.

The availability of federal funds for academic research and the general expansion of higher education in the 1950s and 1960s also drew students away from careers in industrial research. With the prospects of faculty appointments (often with promises of early tenure) in growing departments or at new "centers of excellence," new Ph.D.s naturally opted for academia over industry. And most professors were delighted to train their best students in their own images for careers in academic research. In an expanding era it was all too easy to believe that only the second rate student or worse need be relegated to industrial, government, or non-research teaching positions.

To the corporate research manager outside the aerospace and high technology industries, university training seemed less and less applicable to industrial needs. "There is no doubt that the structure of many graduate programs in chemistry has been oriented, unconsciously if not consciously, toward careers in academic research. Since at most a few hundred faculty and postdoctoral positions in chemistry become vacant each year, the bulk of the annual 2,000 or more chemistry doctors

are being unrealistically trained," declares a 1973 report of the American Chemical Society.[1] "Too many [candidates for employment] are overspecialized in [their disciplinary] training and are not interested in broadening their horizons," writes the Vice President for R&D of Koppers Company.[2] Send us "well trained graduates, free of anti-business bias," says the General Manager of Research at Stanford Oil (Indiana).[3] While industrial research managers undoubtedly have registered similar complaints in earlier years, concern over the imbalance between academic training and industrial research needs seems to have reached a peak in the late 1960s and early 1970s. Student protests against large corporations (among other institutions) at that time also contributed to the perceived weakening of university relationships with industry.

3. Declining basic research in industry.

A third factor contributing to weakened university-industry links was industry's diminishing role in basic research. As discussed above, industry's share of basic research spending declined steadily between 1955 and 1972, and the proportion of industry's own R&D funds spent on basic research dropped dramatically after 1966. Beyond these overall national statistics, discussions with individual corporate research managers confirm that industry's emphasis has shifted from basic to more applied research during the past decade. Rampant inflation, an uncertain economy, and increased government regulation, among other factors, have led to corporate decisions to favor projects with short term payoffs. In a widely quoted article titled, "The Breakdown of U.S. innovation," *Business Week* magazine reported:
"...there is a growing sense that something has happened to American

---

[1] *Chemistry in the Economy*, American Chemical Society, Washington, D.C., 1973, p. 445.

[2] Maclay, W. N., "Science-Engineering Education for Industrial Research," *Research Management*, September 1974, p. 34.

[3] White, P. C. and C. C. Wallin, "What Industry Needs from Academia," *Research Management*, September 1974, p. 30.

innovation....Within a growing number of companies, such changes and pressures have led to a reappraisal of corporate goals and the emergence of what one top research scientist dubs 'the MBA syndrome,' a super-cautious, no-risk management unwilling to gamble on anything short of a sure thing."[1]

Industry's shift away from basic research makes developing working relationships with universities more difficult. The key to knowledge transfer in general, and to effective research links between universities and industry in particular, is face-to-face, scientist-to-scientist contact. As Robert Sproull has observed from his career in both university and industrial research administration: "The most effective impedance transformer between industry and the university has been and is the able, articulate industrial scientist or engineer who visits a university to give a seminar and who talks informally with students in the lab."[2] Or as Jacob Goldman, chief scientist of Xerox Corporation, puts it, "your admission ticket to the [basic research] club is to have something of your own to talk about."[3] As industry's commitment to basic research has declined, firms have generated fewer such admission tickets, and industrial scientists' links with their university counterparts have weakened commensurately.

International Comparisons

Despite these evident problems, the United States still appears to be a model of close working relationships between universities and industrial firms, from the perspective of other nations. The 1970 report of the U.K. Working Party on Universities and Industrial Research praises the "tradition of close collaboration between universities and industry"

---

[1]"The Breakdown of U.S. Innovation," *Business Week*, February 16, 1976, pp. 56-58.

[2]Sproull, R. L., "The Industrial-Academic Interface: From the Academic Viewpoint," *Research Management*, May 1969, pp. 219-226.

[3]Goldman, J. E., "The Need for Basic Research in Industry," *Physics Today*, December 1975, pp. 23-25.

in the United States, citing federal funding in research in universities and industry, university entrepreneurship (the Route 128 effect), and faculty consulting for industrial firms.[1] Comparative studies of the organization and financing of basic research in Europe and North America by the Organization for Economic Cooperation and Development (OECD) also point to the United States' success in developing effective university-industry relationships.[2] The OECD reports note the importance of informal contacts between university faculty and industrial scientists, faculty consulting, and personal mobility in the United States. The OECD review of the "research systems" in Germany, France and the United Kingdom observes that "each [country] still looks with something approaching envy to the United States" in fostering strong industry-university links.[3]

Prospects for Closer Relationships

One sees signs, however, that the low point in university-industry relations was reached in the early 1970s, and the trend is now toward forging stronger links between the two sectors. First, there is increased recognition of the need for a strong research base to support U.S. economic growth and innovation. As national attention has shifted away from space and defense toward energy, environmental, and economic concerns, the links between research, technological innovation, and productivity assume greater importance.[4] And concern for strengthening these links leads naturally to an interest in improving

---

[1] Confederation of British Industry, *op. cit.*, p. 108.

[2] *The Research System*, Organization for Economic Cooperation and Development, Paris, Vol. 1: France, Germany, United Kingdom, 1972; Vol. 2: Belgium, Netherlands, Norway, Sweden, Switzerland, 1973; Vol. 3: Canada, United States, General Conclusions, 1974.

[3] *Ibid.*, Vol. 1, p. 249.

[4] For a discussion and list of current papers on this topic, see Gilpin, Robert, "Technology, Economic Growth, and International Competitiveness," *A Report Prepared For the Use of the Subcommittee on Economic Growth of the Joint Economic Committee, Congress of the United States*, Washington, July 9, 1975.

ties between universities and industry. Recent speeches and Congressional testimony by both government officials and industry executives call for increased support for university research to provide the foundation for future technological innovation and economic growth. The theme is well expressed by the past president of the Industrial Research Institute:

> "...as a start, there must be strong support by government and industry for a major commitment to undirected basic research at the universities - a commitment to level of funds and to mechanisms for distribution. Only if we can be assured of a strong, viable university structure in its own right do we then have the basis for the integration of some added university efforts into broad national missions."[1]

For their part, universities also are seeking to rediscover their "traditional" ties to industry. This seems principally to reflect a real research interest in the difficult issues relating to the civilian economy, an awakening "respect for applied problems" in Harvey Brooks' phrase. But other, more practical matters are certainly involved: the availability of government funds for applied and productivity related research; greater university interest in industrial research support to supplement a static or declining federal share; changes in graduate student employment expectations; and a recognition that continuing education for industry may become a major source of university support in the 1980s and beyond.[2] Whatever the mix of motives, university faculty and administrators seem considerably more interested in strengthening their research ties to the private sector than they were five years ago. This appears especially true in the most prestigious universities at which anti-industry protests and attitudes were strongest in the late 1960s.

---

[1] Fusfeld, Herbert I., "Industry/University R&D: New Approaches to Support and Working Relationships," *Research Management*, May 1976, p. 24.

[2] Swalin, R. A., "Improving Interaction between the University and the Technical Community," *Research Management*, May 1976, pp. 25-27.

Industry-University Collaborative Research Projects

Consulting and the exchange of people (e.g., an industrial scientist serving as a visiting professor, or a faculty member spending a summer or sabbatical in industry) are the most direct ways of linking academic and industrial research. They are probably also the most effective means of transferring knowledge between the two sectors. Beyond these direct links, however, universities and industry have tried a number of mechanisms to encourage closer collaboration, as listed in Table 4 and described briefly below.[1] These can be broadly divided into efforts to organize collaborative research projects and efforts to improve the overall environment for knowledge transfer, although some programs have both objectives. In the past five years, NSF, the Small Business Administration, and the Department of Commerce have supported several projects in these categories.

1. Direct Corporate Funding of University Research.

Although universities have always sought unrestricted research grants and endowment funds from industry, some have been wary of accepting corporate grants for specific projects or fields of research that might confer proprietary advantages to the donor. These attitudes may be changing, however, as universities seek industrial support more aggressively and decide to take more active roles in the technology transfer process. As one example, Harvard University and the Monsanto Company announced in February 1975 that Monsanto had agreed to provide up to $23 million for a twelve year program of biological and medical research at Harvard. "In return," according to newspaper accounts, "Monsanto will have the opportunity to develop and distribute any medical materials growing out of the research."[2] This includes giving the company exclusive licenses for a period of time to inventions made in connection with the

---

[1] Roy, op. cit., discusses several of these institutional mechanisms in more detail.

[2] "Monsanto, Harvard Join in Project," *St. Louis Post-Dispatch*, February 6, 1975, p. 18.

Table 4. Examples of University-Industry Collaborative Arrangements

Mechanisms to Encourage Collaborative Research

1. Direct corporate funding of university research projects
2. Cooperative (cost sharing) research programs
3. University-industry research consortia
4. Joint industry-university laboratories

Mechanisms to Encourage Knowledge Transfer

1. Consulting
2. Technology licensing and technological brokers
3. Extension services
4. Industrial Associates programs
5. Industrial parks
6. Innovation Centers
7. Small Business Institutes

Monsanto supported research.

According to Harvard officials, Monsanto and the University have created a special advisory board of individuals not connected with either institution to review plans for publication, dissemination of information, and use of discoveries made under the program. In particular, the board has authority to require sublicensing of an invention if it believes it is necessary in the public interest. Still, this arrangement represents a substantial step away from some university policies that do not permit a firm to hold proprietary rights to inventions arising from university research it supports.

Bilateral arrangements between a university and an industrial firm generally result in strong person-to-person interactions that favor technology transfer. The firm presumably supports the research in expectation of a net economic return. In the past, such industrial support has typically been on a project-by-project and year-by-year basis.[1] In hard times these projects are often the first to be cut off. In contrast, the Harvard-Monsanto arrangement represents a long term, high level commitment by the company to support basic science in return for closer links to university research and some proprietary advantages. Whether other universities will follow Harvard's example and offer substantial proprietary rights in exchange for substantial industry research support remains to be seen.

2. Cooperative Research Programs.

In some cases individual firms may be willing to pay for part, but not all of the cost of a university research project. If the project offers

---

[1]Compare, for example, the approach described by Alcoa's Vice President for Science and Technology: "The device used...is to tell a young industry researcher to visit the university which is doing the best work in his field, then provide him with a check, in Alcoa's case for $5,000, which the young industry representative can leave with the professor to help support a graduate student or to provide general support for the work, but to leave it only if he thinks the work being done is good and useful. Since most professors hope the industry representative will visit again next year with similar results, there is a real incentive to communicate and to establish a lasting relationship." Walker, Eric A., and Robert G. Hampel, "Improving Industrial R&D - University Relations," *Research Management*, September 1974, pp. 23-28.

prospects of educational or social benefits (such as creating jobs), the remaining costs may be paid for by a government agency, a private foundation, or the university itself. Federal support for such cooperative research can also be justified in cases of market failure where individual firms cannot recoup the benefits from R&D and consequently conduct less research than is socially optimal. These arguments were used in the early 1960s to support cooperative research between universities and textile firms under the short-lived Civilian Industrial Technology (CIT) program in the Department of Commerce. At present the National Science Foundation under its RANN program sponsors at least three cooperative research programs at Carnegie Mellon University, North Carolina State University, and MIT. (Another program operated by MITRE under the RANN cooperative research program is actually a form of technology brokerage, as described below).

The Processing Research Institute (PRI) at Carnegie-Mellon University was funded by NSF in 1971 to develop a Master of Engineering program oriented toward the processing industries. Cooperative research projects supported by individual firms form an integral part of the PRI program. In the three and a half years between January 1972 and June 1975, 26 firms and industry associations paid approximately $800,000 to support 34 separate research projects.[1] The PRI provided another $500,000 in matching funds from its NSF grant. The firms sponsoring research projects at PRI were large industrial corporations heavily involved in R&D, including duPont, Exxon, Xerox, Westinghouse, Alcoa, and Ford. Few companies with annual sales below $100 million have participated in the PRI program.

The PRI program uses cooperative research projects principally as a vehicle for involving graduate students in problem-oriented research directly relevant to industrial needs. The program is not aimed at improving productivity in participating firms, nor is it addressed to any specific market failures. It is by no means clear, for example, that the federal contributions to PRI research projects do not simply substitute

---

[1] "Fourth Annual Progress Report," Processing Research Institute, Carnegie-Mellon University, June 1975.

for the funds the companies would have spent on research anyway, albeit in their own laboratories and not at Carnegie-Mellon. Nevertheless, the PRI program stands out as a direct effort to use federal funds as a catalyst to reorient university engineering studies toward industrial interests.

Similarly, the RANN funded Polymer Processing Program at MIT seems directed toward large firms with substantial R&D capabilities in the plastics industry. Although one of the principal goals of the program, outlined in the MIT proposal, is "To recommend alterations in public policy which would result in increased R&D investments and efforts by small firms,"[1] the five initial industrial participants are large corporations with annual sales ranging from $40 million to over $10 billion. According to a preliminary evaluation, the MIT program has been successful in generating "a great deal of informal interaction...between the program staff and industrial members....For example, Dr. Suh [the Program Director] is often asked to act as a consultant when specific problems are encountered by a member firm. A high degree of satisfaction with the program is indicated by member firms."[2]

In contrast, the RANN sponsored cooperative research program at North Carolina State University is directed toward the U.S. furniture industry which is highly fragmented and has little current R&D capability. Six furniture manufacturing firms participate in research projects with the university. As might be expected, establishing effective links has been more difficult in this case than when companies with substantial R&D programs of their own are involved. The preliminary evaluation reports that the Furniture R&D Applications Institute "is not meeting the cost sharing goal," and that "the depressed economy has had substantial negative impacts on the development of the program. Industrial members hesitate to implement innovative processes and change furniture design when their

---

[1]Grad, Marcia L. and Joseph Halpern, "Evaluation Status and Planning, Cooperative Research and Development Experiment," Report R 75-07 prepared for Experimental R&D Incentives Program, National Science Foundation by the Denver Research Institute, October 1975, p. 23.

[2]Ibid, p. 26.

revenues are uncertain and decreasing."[1] Moreover, the evaluation notes that "The institute's establishment was announced in the trade publications, and presentations have been made to the National Association of Furniture Manufacturers...and the Forest Products Research Society....No results have been observed from these efforts."[2]

While it is still too early to judge the final results from NSF's efforts to stimulate cooperative research, these three contrasting examples reinforce the conventional wisdom that universities can more easily create research partnerships with large, technically sophisticated companies than with small firms.

3. University-Industry Research Consortia.

Another approach to strengthening university-industry links is to create research consortia with well-defined applied research objectives. Roy has described how the Department of Defense successfully adopted this approach for developing military technology such as coatings for refractory metals in supersonic aircraft.[3] A group of experts in the field defines the key research needs, solicits proposals from both university and industry groups, selects the best proposals for funding, and coordinates the reporting and publication of results. A key to success appears to be holding regular, informal meetings of consortium members to discuss their ongoing work in addition to reporting completed results.

An example of such a consortium in a non-military field is that organized by Clemson University with support from the Experimental Technology Incentives Program (ETIP) of the Department of Commerce to conduct research on fabric flammability. ETIP viewed the consortium as a vehicle to speed the commercialization process from laboratory research to demonstration to subsequent diffusion. The consortium includes three universities,

---

[1] Grad and Halpern, op. cit., p. 18.

[2] Ibid., p. 18.

[3] Roy, op. cit.

a nonprofit laboratory, a government laboratory, and four private firms.[1] Although in operation for only two years, the consortium seems successful in linking university research to industrial needs and in stimulating additional industry R&D.

A second example is the Coordinating Research Council Air Pollution Research Advisory Committee (CRC-APRAC), formed in 1968 to collect information and commission research on automobile air pollution. Financial support has been provided by the Motor Vehicle Manufacturers Association, the American Petroleum Institute, the Engine Manufacturers Association, and until 1973 the Environmental Protection Agency. While CRC-APRAC contracted most of its research with industrial laboratories, several university medical schools received funds for research on the effects of air pollutants on human health. University scientists also sit on several of the CRC-APRAC advisory groups.[2]

On balance, research consortia including universities and industry appear most productive when they are directed toward a specific, mission-oriented goal. This usually requires a federal agency or other sponsor to provide the rationale and initial financial support for the consortium. Success also requires vigorous leadership. If the consortium has this leadership -- that is, if it is willing to set research priorities, bring the participants together to discuss and critique each other's work, and otherwise act as a strong research coordinator, it can serve to build effective ties between universities and industrial firms. ERDA has indicated its interest in establishing university-industry research consortia of this sort for research on energy problems.

Some states also are taking active roles in creating consortia of state and local government agencies, universities, and industrial firms to conduct research on issues of state concern. The motivation is principally to see that the state receives its share of federal R&D funds.

---

[1] Rettig, Richard A., "The Use of Consortia for the Management of Research and Development: Some Initial Observations on the Clemson University ETIP Project," presented at the Clemson University Special Symposium on Flammability and Flame Retardation of Polyester/Cotton Blend Fabrics, Clemson, South Carolina, September 15-17, 1976.

[2] *CRC APRAC Status Report*, Air Pollution Research Advisory Committee of the Coordinating Research Council, Inc., New York, January 1975.

Michigan, for example, established in 1975 the Michigan Energy and Resource Research Association (MERRA), whose members include state government agencies, large industrial firms such as Dow Chemical and Detroit Edison, and major universities including Michigan State University, Michigan Technological University, the University of Michigan, and Wayne State University. MERRA's stated purposes are to aid the creation of research consortia among its members, to identify research projects and likely funding sources, and to help obtain research support for these projects.[1] As examples, MERRA has endorsed research projects for in-situ oil shale retorting, involving Dow Chemical and several Michigan universities; and for conversion of municipal waste to methane, involving a private engineering firm and researchers at Michigan State University and the University of Michigan. MERRA also has been actively seeking to have the new ERDA sponsored Solar Energy Research Institute located in Michigan. Several other states reportedly are considering emulating the MERRA model to enhance their competitive positions for energy R&D funds.

A different model is illustrated by the Gulf Universities Research Consortium (GURC) that brings together research groups from several universities to conduct environmental research sponsored by government and industry. The consortium is controlled by the universities, with industrial firms, nonprofit research institutions, and government agencies involved as Research Associates or Affiliates. While such consortia may be useful in promoting cooperation among universities and in obtaining research constracts, they are less likely to build strong working relationships between universities and private sector firms.

4. A Joint Industry-University Laboratory.

Part-time use of specialized research equipment in universities by industry personnel, or vice-versa, is not uncommon. University managed contract research centers that engage in some research for industry are also familiar. Much more unusual is the actual merger of university and industry laboratories into a single entity under joint control. One such

---

[1] *MERRA '75 Annual Report*, Michigan Energy and Resource Research Association, Detroit, 1976.

example is the Fluid Dynamics and Energetics Laboratory of New York University (formerly the Aerospace Laboratory) which in 1973 was combined with the General Applied Science Laboratories (GASL), a for-profit company.

In 1973 New York University sold its University Heights campus and transferred most of the technical equipment, along with the faculty in the School of Engineering and Science, to the Polytechnic Institute of New York. However, the Polytechnic Institute already had facilities similar to those of the NYU Fluid Dynamics and Energetics Laboratory. Consequently, after consideration of several other alternatives, the NYU laboratory's equipment and technical operating staff were merged with those of GASL. While the physical facilities of the two laboratories have been combined, the professional staffs remain organizationally separate, and NYU and GASL use separate accounting systems for their operations. A number of complex legal and administrative issues remain, such as the disposition of government furnished equipment and the cost apportionment of common services, but in principle these problems appear to be workable. A recent management study also suggests that this arrangement can serve as a model for industry-university collaboration.[1] However, the NYU-GASL merger seems a forced marriage of necessity which, because of the basic differences between universities and for-profit organizations, is not likely to be replicated voluntarily.

Encouraging University-Industry Knowledge Transfer

Besides collaborative research, a variety of devices have been tried to speed the transfer of knowledge from university research to industrial application. Some have received active government support in the past five years. The arrangements described below are by no means exhaustive; a more complete list is contained in the 1970 U.K. Report of the Working

[1] Ragazzini, John R., "Management Study of a Merged Large-Scale Fluid Dynamics (and Energetics) Laboratory - A Joint University-Industry Venture," New York University, July 1976.

Party on Universities and Industrial Research.[1]

1. Consulting.

Faculty consulting appears to be a very effective means of transferring knowledge from the university to industry. It is also a good way for the university professor to gain an understanding of industrial research needs and an appreciation for the problems of commercialization. Consulting is a clear example of a market transaction, with presumed benefits for both parties.

Regrettably, little data exist on university consulting to industry. Large companies report using university consultants more often than small firms. A 1965 survey of University of California faculty members found that about 30 percent had some consulting activities during that year.[2] The highest percentages of consulting were reported by faculty in medicine, engineering, and social science. A 1969 survey of about 2500 business school faculty reported that 40 percent were paid consultants to private firms. Over half of the responding faculty members in private universities were consultants, compared with about one-third of public university faculty. Moreover, the percentage of business school faculty employed as consultants to national corporations increased with the prestige of the university.[3] No such variation was found for local consulting. Finally, an ACE survey taken during the 1972-73 academic year found that 48 percent of responding university faculty members reported some paid outside consulting in the past year.[4]

These data are too meager to suggest any trends in university consulting for industry. Anecdotally, reports circulate about specific companies

---

[1] Confederation of British Industry, op. cit., p. 112.

[2] Perry, Dallas K., "Sample Survey of Faculty Supplementary Employment and Income During 1965: University of California and California State Colleges, Final Report," System Development Corporation, TM-L-2789, December 30, 1965.

[3] Kruytbosch, Carlos E. and David D. Palmer, "Academic Role Performance and Organizational Environment," School of Business Adm., Univ. of Connecticut, 1976 (processed). University prestige was determined by "peer-based prestige ratings of institutions," according to the authors.

[4] Bayer, Alan E., "Teaching Faculty in Academe: 1972-73," American Council on Education, ACE Research Reports, Vol. 8, No. 2, August 1973.

that have abandoned or cut back on university consulting because of financial problems; on the other hand, one hears cases of firms that have begun using university consultants on a more systematic basis. Several corporations heavily involved in R&D, for example, have recently established Technical Advisory Boards including academic consultants to review their overall R&D strategies and programs.[1] Better data on faculty consulting to industry (perhaps as one of the NSF science indicators) would be helpful in observing trends in university-industry interactions.

2. Technology Licensing and Technological Brokers.

The concept of a broker to bring universities with research capabilities together with industrial firms with research needs has intrinsic appeal. Several types of brokers now exist. University research foundations that license patents derived from university research perform this sort of brokerage function.[2] Other universities use Battelle Development Corporation or Research Corp. for licensing or otherwise commercially exploiting their inventions. And a few private consulting firms such as Dr. Dvorkovitz & Associates specialize in technology brokerage between universities and industrial firms. Since 1973 Dr. Dvorkovitz & Associates has sponsored an annual University/Industry Forum at which universities can display their technologies for license to industrial firms. The February 1976 meeting, called the "First World Fair for Technology Exchange," drew more than 2000 attendees, according to the firm. Although quantitative data on the extent of university technology licensing again are unavailable, both universities and commercial firms seem to be showing increased interest in this kind of technology transfer.[3]

---

[1] Bacon, Frank R., Jr. and Thomas W. Butler, Jr., "The Technical Board," attachment to "Identifying Needs and Resources for Knowledge of Science," a paper delivered by Thomas W. Butler, Jr. at the annual meeting of the American Association for the Advancement of Science, February 1976.

[2] Daniels, Raymond D., Ralph C. Martin, Lawrence Eisenberg, Jay M. Lewallen, and Ronald A. Wright, "University-Connected Research Foundations, An Introduction," *SRA Journal*, Spring 1976, pp. 16-25.

[3] Rawls, Rebecca L., "University technology licensing set to rise," *Chemical and Engineering News*, August 25, 1975, pp. 11-12.

Federal agencies have in the past supported dissemination centers or clearinghouses at universities to speed the flow of research results to potential industry users, but their effectiveness as agents of technology transfer remains in doubt.[1] More recently, NSF has funded a direct brokerage experiment as part of its cooperative research program. The New England Energy Development System (NEEDS) Center, developed by the MITRE Corporation, is intended "to facilitate the flow of technology between the New England electric utilities and those universities/non-profit research groups capable of performing research needed by the utilities."[2] The NEEDS center tries to match research performer and utility user on individual projects, publishes summaries of research results on specific topics, and conducts seminars for industry, government, and university participants. However, it is not clear why such a government supported center is necessary for dealing with electric utilities that have their own, industry supported R&D programs through the Electric Power Research Institute, as well as some established links with universities and other research performers. Without an identified market failure, a government subsidized technology broker may simply substitute for other linking mechanisms provided by the private sector and the universities themselves.

3. Extension Services.

The USDA Agricultural Extension Service, which along with the Agricultural Experiment Stations is closely tied to land grant universities, is repeatedly cited as a model for knowledge transfer in other fields. A 1963 report by Arthur D. Little, Inc., for example, recommended an extension service for the building construction industry modeled after the agriculture experience.[3] Some of the ideas contained in the A. D. Little report were subsequently embodied in the Department of Commerce's Civilian Industrial Technology program, but this part of the CIT program was never

---

[1] Doctors, Samuel I., *The Role of Federal Agencies in Technology Transfer*, The M.I.T. Press, Cambridge, 1969, pp. 92-127.

[2] Grad and Halpern, op. cit., p. 29.

[3] Nelkin, Dorothy, *The Politics of Housing Innovation*, Ithaca, New York, Cornell University Press, 1971, pp. 25-26.

approved by Congress. Other proposals in the past ten years have called for extension services to aid local government, vocational rehabilitation, marine activities, pollution control, and energy conservation, as well as industrial technology generally.[1]

In June 1976, Texas A&M University organized the Energy Advisory Service for Texas (EAST). As an extension service, its purpose is to provide "direct contact of energy technology specialists with energy-user groups. The specialists [will] work with manufacturers, builders, operators of buildings, and the general public to perform energy audits and to analyze the potential payoff of energy conservation strategies."[2] EAST receives support from the University's state funds, the Texas Governor's Energy Advisory Council, Public Technology Incorporated (a non-profit organization financed largely by NSF to stimulate technology transfer for local public services), and ERDA. Independently, ERDA is now considering establishing energy conservation extension services throughout the United States.

Proponents of new extension services emphasize the value of decentralized operations, grass roots knowledge, and adaption to local problems and needs. These characteristics of the Agricultural Extension Service are well linked to the decentralized and locally varying farming operations throughout the nation. In general, extension services seem most appropriate for fragmented markets where the cost of obtaining information about new developments is high. Energy conservation for residential and commercial buildings may be one such example. Extension services are expensive to operate, however, especially if they must be created anew for each application. Building on an existing agricultural extension service, as Texas A&M has done for energy conservation, seems a more sensible approach.

---

[1] "Technology Policy Proposals," *Science Trends*, October 4, 1976, pp. 139-140.

[2] Ritter, Stephen, "The Energy Advisory Service for Texas," paper presented at the 1976 Summer Workshop on Energy Extension Services, Berkeley, California, July 1976 (processed).

4. University Industrial Associates.

A few universities successfully run Industrial Associates programs, in which member companies each contribute a set fee annually -- usually $15,000 to $25,000. The funds are used for general university purposes rather than for specific research projects. In return, Industrial Associate members can receive publications, attend special conferences and seminars, arrange campus visits for corporate research staff and executives, and meet individual faculty members. Industrial Associate members do not expect to receive proprietary information from their campus contacts, but they can use their favored status to exchange research results in fields they are actively pursuing and receive intensive briefings in unfamiliar areas by a competent authority. Consulting by a faculty member often grows out of an Industrial Associate contact, but that is an entirely separate arrangement.

Only a few of the nation's most prestigious academic institutions, such as MIT, Stanford, and Caltech, have successfully run Industrial Associate programs. Several universities that have attempted to institute them have failed to achieve the critical mass of corporate members needed to defray the costs of running the program.

5. Industrial Parks.

Creating an industrial park near campus has been contemplated by many universities as a way to strengthen interactions with industry. It has also had considerable financial attraction to universities with available land nearby. The most successful example is the Stanford Industrial Park that has attracted a large number of research intensive companies and their spinoffs to locate near the Stanford campus. The results in terms of encouraging faculty consulting and entrepreneurship, industrial staff enrollments in university courses, and the use of industrial scientists as university lecturers, are generally considered to be significant stimuli to technology transfer.

Other universities have emulated the Route 128 and Stanford examples with greater or less success. A particularly ambitious project has been the Research Triangle Park, developed with strong backing from the State of North Carolina and associated with the University of North Carolina

at Chapel Hill, North Carolina State University at Raleigh, and Duke University at Durham. Along with the industrial park, the three universities joined to establish the Research Triangle Institute (RTI) as an independent, nonprofit research organization. The Institute's Board of Governors includes state government officials and representatives from corporations located in the Research Triangle Park, as well as university officials. Many university faculty members serve as consultants or part time staff members at the Institute and work on industry sponsored research.

A university decision to pursue an industrial park development certainly will be based on criteria other than fostering university-industry research relationships. It will demand very strong political and financial commitments by the university, and generally by the local government as well. And it seems clear that only a limited number of universities can successfully follow the Stanford and RTI examples.

6. Innovation Centers.

Another group of National Science Foundation experiments intended to foster productivity in U.S. industry are the three "innovation centers" supported at the University of Oregon, MIT, and Carnegie Mellon University. The innovation centers are intended to teach the skills necessary to move a new product from the laboratory to the marketplace, as part of a graduate degree in business or engineering. The centers also provide support for individual inventors. If successful, the innovation centers should strengthen the links between universities and the industrial firms that will manufacture and market the new products.

In June 1973 NSF awarded a total of $3 million to these three innovation centers over five years. It is too early to assess their results in terms of strengthening university-industry relationships, but they have generated considerable enthusiasm on the part of students, faculty members, and industry executives. As one example, five students at the MIT Innovation Center developed new electronic games in response to the interest displayed in marketing them by a small local company. A marketing contract with the company was signed in April 1975. According to the Center's Director, "By the middle of July orders for 400,000 units had been obtained

from major retailers around the country. Production began on November 28, 1975. The contractor has hired seventy new employees and has created a pool of an additional 100 people upon which to draw as production expands."[1] Overall, the NSF program director estimates that "during the first two years, the Centers contributed to the creation of 240 new jobs and $3.4 million in sales."[2]

7. University Business Development Centers.

At least a half dozen federal agencies, including HEW, the Small Business Administration, NSF, the Economic Development Administration, the Office of Minority Business Enterprises, and the National Bureau of Standards support programs at colleges and universities to assist small businesses. They principally offer management consulting and training in such field as accounting, economics, contracting, and business law. The Small Business Administration has recently announced the formation of University Business Development Centers (UBDCs) that would coordinate these several agency efforts.

Universities and colleges that participate in UBDC programs generally are urban, community oriented institutions with little ongoing research. Consequently, while these small business programs may stimulate technology transfer indirectly (by helping establish new firms that may then acquire technology from universities), their direct effect on university research links with industry appears quite small.

CONCLUSIONS: MAINTAINING A STRONG UNIVERSITY ROLE IN A PLURALISTIC R&D SYSTEM

While this paper has tried to be a descriptive rather than normative, the discussion of research performers and their interactions leads to several judgmental conclusions. First, university strength in basic research seems undiminished despite the financial and institutional strains of the last decade. If anything, universities have strengthened their position as the predominant U.S. performer of basic research. Both the

---

[1] Li, Y. T., "Development of Future Innovators and Entrepreneurs," paper delivered at the annual meeting of the American Association for the Advancement of Science, February 1976.

[2] Colton, Robert M. and Gerald G. Udell, "The National Science Foundation Innovation Centers-An Experiment in Training Potential Entrepreneurs and Innovators," *Journal of Small Business Management*, April 1976, pp. 11-20.

industrial and government sectors stress the importance of supporting university basic research as a foundation for mission-oriented applied research and development by other performers.

In applied research and development, universities face strong competition from industry, government laboratories, and nonprofit research institutes; and have shown few comparative advantages in relation to these other performers. Concern for relevance in university research remains, but it has lost much of its strident sound from the late 1960s. And while "national needs," "technology transfer," and "community service" will continue to motivate or justify additional university research, these goals seem unlikely to overwhelm the traditional university objectives of fundamental research and education. The limitations of the multiversity have clearly been identified in the past decade.

In terms of research support, the federal government seems inevitably to remain the principal patron of university research. The roles of state and local governments seem likely to increase as more federal funds flow through them. Neither industry nor foundation support of university research shows signs of regaining the importance it held before 1955, although such support obviously can be important in many specific cases.[1]

The nation's growing concern for civilian problems and U.S. economic competitiveness focuses attention on university research links with the industrial firms. Both sectors have pledged to rectify their past neglect and to establish "better" university-industry relationships. Strengthening the links, however, will encounter conceptual as well as practical difficulties. Universities and industrial firms have different objectives, different incentive schemes, and different approaches to research that will not be bridged by mere rhetoric.[2] Nor is it clear how closely the two

---

[1] Abelson, P. H., "Additional Sources of Financial and Political Support for Science," *Science*, April 20, 1973.

[2] Perusal of the recent literature makes it easy to agree with the observation of one reviewer of the 1970 Confederation of British Industry report, "if the idea of collaboration between university and industry is buried underneath sufficient platitudes it will die of suffocation." Freshwater, D. C., "Industry, Science and Universities," *Chemistry and Industry*, March 20, 1971, pp. 320-321.

sectors *should* be intertwined. The nation has profited from its set of diverse research institutions, and some competitive tension among the sectors seems more healthy than debilitating.

Still, there is much we can do to dispel the myths that have made university-industry relationships more difficult than they need be. Changing attitudes and expectations among university faculty, students, industrial scientists, and research administrators certainly seem helpful. And some additional government support may be useful in lubricating the pathways and experimenting with new ideas.

But one must view present federal programs aimed at strengthening university-industry interactions as rather unstructured, unfocused, and uncoordinated. Some are meant to aid small businesses; some to improve productivity in R&D-lagging industries; some to spread research funds geographically and spur regional development; and some to tailor university engineering to the needs of large, technically sophisticated firms. Few seem directed toward identified market failures or government-induced obstacles to technology transfer. And most government programs seek to effect the links through the university supplier of research, rather than the industrial producer of goods and services.

Federal programs to strengthen university-industry interactions seem to suffer from the same difficulties observed on a much larger scale in government efforts to commercialize new technology directly: too much technology push, too little demand pull, and not enough concern with the incentive systems that influence the transfer of ideas from research to application.[1] Yet there are models that we know work. Perhaps federal programs should promote consulting and other exchanges of *people* between universities and industry, from which the transfer of knowledge may naturally follow. Perhaps more projects should focus on the industrial manufacturer or user of the technology rather than on the university

---

[1] See, for example, Gilpin, *op. cit.*; and Baer, Walter S., Leland L. Johnson, and Edward W. Merrow, *Analysis of Federally Funded Demonstration Projects: Executive Summary*, The Rand Corporation, R-1925-DOC, April 1976.

supplier. The Director of the Rockwell International Science Center puts the matter bluntly: "I have a basic thing about universities getting funds to solve hydrogen embrittlement problems when they don't have any."[1] And perhaps federal agencies should insist that proposals for collaborative research include a marketing or commercialization plan, as ETIP did in the fabric flammability program, rather than a dissemination plan. In any event, we need to develop better conceptual and evaluative frameworks for government programs to strengthen university relationships with industry.

Universities and private sector firms seem anxious to rediscover and reinforce the ties between them. Specific government programs may help cement these relationships, but their importance is by no means clear. Like other aspects of technology transfer, effective university-industry links depend most on the two partners' own incentives to promote the flow of people and ideas.

---

[1] Loucks, *op. cit.*, p. 35.